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See page 17, June 1. 1134

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See Advertisement page 69.

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See Advertisement page 60, June 1. 2402

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See Full Page Advt., page 59, May 25.

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Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1401

Fuel Economy.—Well-known Expert is OPEN to ACCEPT STUDENTS for Correspondence Course of Instruction in Combustion Engineering, etc.—Particulars, fees, etc., write IGNITION, 171, Warminster Road, Sheffield. A 746

TENDERS.

The Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, REQUIRES:—
STEEL TYRES for Locomotive Engines and Tenders. Tenders due Two p.m. on the 26th June, 1923.
Tender Forms obtainable from the above. A 734

BRITH URBAN DISTRICT COUNCIL.

AIR-COMPRESSOR, ELECTRIC MOTOR, ETC.

The Council invite

Tenders for the Supply and INSTALLATION of ONE HORIZONTAL TYPE AIR-COMPRESSOR, ELECTRIC MOTOR, Etc., together with Steel Framework for extending existing platform at the Council's Sub-Station, West Street, Brith. Further particulars and Form of Tender may be obtained at the office of the undersigned.
Sealed Tenders, endorsed on the envelope "Air-Compressor," to be delivered at this office not later than Tuesday, the 19th June, 1923.
HAROLD HIND,
Engineer and Surveyor.
Council Offices, Brith,
5th June, 1923. A 766

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

		Fee for Specification.
1.	Laminated Springs	£1
2.	Crank Axles (Machined) for Locomotive Engines	10/-
3.	Steel Tyres for Locomotive Engines and Tenders	£1
4.	Ropes and Twines	5/-
5.	Drawn Brass Angles, &c.	2/6
6.	Galvanised Corrugated Sheets, &c. ...	7/6
7.	Plate Glass, &c.	7/6
8.	Mild Steel Cotters	7/6

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Laminated Springs," or as the case may be, not later than 11 o'clock a.m., on Tuesday, the 19th June, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE,
Secretary.
Company's Offices,
46, Copthall Avenue, E.C.2.
London, 6th June, 1923. A 770

SOUTH ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.
Copies of Tender Form and Specification will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.
SPECIFICATION No. 23/77.
ALUMINIUM STEEL CORED CABLE
0.0707 SQ. IN.
CHARGE:—£2 for the first three copies of Tender Form, Conditions of Contract, Specification complete. These charges will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. each.
PRELIMINARY DEPOSIT:—A preliminary deposit of £100 is to be lodged with the Tender.
The Specification may be inspected at the above-mentioned office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 31st August, 1923.
R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. A 639

GREAT NORTHERN RAILWAY (IRELAND).

TO BRIDGE CONTRACTORS.

The Directors are prepared to receive

Tenders for Reconstruction of BRIDGE No. 57, between Drogheda and Dunleer.
The Drawing and Specification may be inspected at the Engineer's Offices, Dublin and Belfast, and copies of same, together with Bill of Quantities and Forms of Tender, may be obtained from the undersigned, on payment of Two Guineas, which will be refunded on receipt of a *bona fide* Tender accompanied by the drawing.
Tenders made out on the Forms supplied by the Company should be delivered under sealed cover, endorsed "TENDER FOR BRIDGEWORK," not later than Ten a.m., on Monday, 25th June.
The Directors do not bind themselves to accept the lowest or any Tender.
J. B. STEPHENS,
Secretary.
Amiens Street Station.
Dublin, 5th June, 1923. A 767

COUNTY BOROUGH OF GRIMSBY. ELECTRICITY DEPARTMENT.

The Corporation are prepared to receive

Tenders for the following:—

SPECIFICATION No. 174.
BOILER HOUSE PLANT.
The Specification comprises two water tube boilers of 21,000 lbs. per hour output, together with economisers, stokers, steel chimney, brickwork setting, dust catcher, fittings, etc.
SPECIFICATION No. 175.
CONVERTING PLANT.
The Specification comprises one 1000 Kw. Converter, one 250 Kw. Converter and L.T. Switchgear, cablework, etc.
Specifications and Drawings may be obtained from the undersigned, and extra copies of same may be obtained on the payment of 7/6.
Tenders are to be despatched so as to arrive not later than Monday, July 2nd.
W. A. VIGNOLES, Lt.-Col.,
Borough Electrical Engineer.
Corporation Electricity Works,
Grimsby.
June, 1923. A 740

METROPOLITAN WATER BOARD.

PRIMARY AND SECONDARY FILTERS, ETC., WALTON-ON-THAMES.

The Metropolitan Water Board invite

Tenders for the Construction of 18 REINFORCED CONCRETE PRIMARY RAPID FILTERS, each about 26 ft. by 16 ft. 6 in., Covered Wash-water Tank, Compressor and Pump House and Stores, Six Concrete Secondary Filters, each about 220 ft. by 170 ft., Clear Water Suction Tank, 58 ft. by 52 ft., Four Sedimentation Tanks and Mud Bays, Two Chlorinating Chambers and Gauge-houses; also the Laying of Inlet and Outlet Mains and Drains, the Construction of Roads and Paths, together with auxiliary works in connection therewith.
Drawings, Conditions of Contract and Specification may be inspected without payment of fee at the Offices of the Board, Chief Engineer's Department (Room 201) on and after 11th June, 1923.
Forms of Tender, Conditions of Contract, Specification and Bills of Quantities, together with Drawings and a spare copy of the Bills of Quantities, may be obtained on and after 18th June, 1923, from Mr. HENRY B. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £20, which sum must be deposited with the Accountant to the Board, and will be returned on receipt of a *bona fide* Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the Bills of Quantities which may be retained by the Tenderer). Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon). Cheques must be made payable to the "Metropolitan Water Board" and not to individuals.
Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, London, E.C.1," and endorsed "Tender for Walton Filters" must be delivered at the Offices of the Board not later than Monday, 9th July, 1923.
The Board do not bind themselves to accept the lowest or any Tender.
G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
New River Head,
173, Rosebery Avenue,
E.C.1.
30th May, 1923. A 741

APPOINTMENTS OPEN.

Chief Engineer Required to take charge of Steam Turbine Dept. of leading firm; must have first-class experience in latest development of Steam Turbine designs and be competent to exercise general control over the Steam Turbine Section of the Company's business and preferably have held a similar position with a recognised Firm of Steam Turbine Builders. Applications from first-class and experienced men only will be considered, and the Firm is prepared to pay a Salary commensurate with the qualifications desired.
Strict confidence will be observed with all applications submitted, which must state age, details of experience and qualifications and salary expected. —Address, in the first instance, A 680, Offices of ENGINEERING.

Required, by an Engineering Company in London, thoroughly capable MECHANICAL and ELECTRICAL ENGINEER, having had experience of Traction work. Must possess good business qualifications, be willing to travel throughout the country, good address, age between 30 and 40. Salary required to be stated by applicant.—Reply, with full details of past experience, to BOX R.O. 1031, c/o DAWSON'S Advertising Service, 121, Cannon Street, E.C.4. A 775

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council REQUIRES in September next, VISITING TEACHERS of the undermentioned subjects:—
(1) WESTMINSTER TECHNICAL INSTITUTE, VINCENT SQUARE, S.W.
Civil Engineers' Specifications, Quantities and Estimates, One evening a week. Expert knowledge and experience in lecturing essential;
(2) PADDINGTON TECHNICAL INSTITUTE, SALTRAM CRESCENT, W.
(a) Mathematics (two evenings a week). (b) Mechanical Engineering (three evenings a week). (c) Electrical Engineering (one evening a week).
Fees (1) 30s., (2) 16s. an attendance of about three hours. Preference given to candidates who have served, or attempted to serve, with H.M. Forces. Apply, Education Officer, (T.1a), The County Hall, S.E.1 (stamped addressed foolscap envelope necessary) for form, to be returned on 20th June, 1923. Canvassing disqualifies.
JAMES BIRD,
Clerk of the London County Council.
A 773

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

A Junior Assistant for Experimental Work in connection with timber-drying kilns is REQUIRED for the FOREST PRODUCTS RESEARCH BOARD. Candidates should be graduates in Engineering, or possess equivalent qualifications, with some practical experience. Knowledge of Botany will be an advantage.
Preference will be given, other things being equal, to ex-service men.
Salary £250 per annum inclusive. A somewhat higher salary might be offered to a candidate of special experience.
Applications, giving particulars of age, qualifications, military service, etc., and enclosing copies of testimonials or names of referees, should be made in writing not later than 18th June, 1923, to SECRETARY, DEPARTMENT of SCIENTIFIC and INDUSTRIAL RESEARCH, 16, Old Queen Street, S.W. 1. A 748

BOROUGH OF KINGSTON-UPON-THAMES.

Technical Institute.

Wanted for the Evening Classes commencing the last week in September, an INSTRUCTOR or INSTRUCTORS in Electrical Engineering and Electrical Installation, four nights per week.
Applications for one, two, three or four evenings per week will be considered.
Salary at the rate of 9s. per hour for the first two hours and at the rate of 4s. 6d. per hour for any period exceeding two hours per evening, together with travelling expenses.
Application forms may be obtained from the undersigned.
H. T. ROBERTS, B.A.,
Education Secretary. A 742

MINISTRY OF AGRICULTURE AND FISHERIES.

Applications are Invited for the APPOINTMENT of a TEMPORARY DRAINAGE INSPECTOR for technical work in connection with Land Drainage. Salary not to exceed £250 (inclusive) plus travelling and subsistence allowances.
Candidates should be experienced surveyors and have had experience of Land Drainage and Reclamation. Preference will be given to ex-Service men.
Forms of application can be obtained from the SECRETARY, MINISTRY OF AGRICULTURE AND FISHERIES, 10, Whitehall Place, London, S.W.1, and must be returned, with copies of recent testimonials, not later than 22nd June, 1923. A 739

Young Engineers, with En- gineering Degree, or equivalent, WANTED for the advertising profession, to be taught to plan and develop complete advertising campaigns. Must be keen, self-reliant, and able to think. Commencing Salary £150 per annum, rising to £500.—Write, BOX 100, ENGINEERING PUBLICITY SERVICE LTD. Regent House, Kingsway, W.C. 2. A 714

One Responsible Engineer REQUIRED in each works as Agent for our Course of Tuition in Automobile Engineering.
SOUTHERN ENGINEERING INSTITUTE,
Newdigate, Surrey. A 752

A Vacancy Occurs for an ELECTRICAL ENGINEER on the staff of a firm of Export Merchants in London. Membership of I.E.E. desirable and a few years' previous experience in export purchasing essential. Applicants should state salary expected, and should apply with copies of testimonials to BOX E.E. 669, c/o DAWSONS' Advertising Agency, 121, Cannon Street, E.C. 4. A 751

Engineer with good Technical Training and Works Experience REQUIRED for experimental work on aero engines. Must be willing to fly as observer. Preference will be given to an ex-service man.—Write, stating age, training, experience and salary required to BOX 313, c/o POTTERS, Imperial House, Kingsway, W.C. 2. A 749

Wanted for Calcutta, a good all-round MECHANICAL ENGINEER, with practical experience in Steam and Pumping Engines. Must be well educated. Age not to exceed 30. Unmarried. 5 year Agreement.—Reply, in writing, to Messrs. ALEX. LAWRIE & CO., 14, St. Mary Axe, E.C. 3. A 753

Wanted, Assistant, Qualified to survey large factory establishment, lay-out dimension and estimate capital costs of installing and operating, expenses of heating plant for building and process heating on low pressure feed with vacuum return system. Experience, qualifications and wage expected.—Address, HEATING, WM. PORTEOUS & Co., Advertising Agents, Glasgow. A 772

Wanted, Highly-skilled TOOLMAKER-MECHANIC, expert at jigs, cutter heads, gauges, etc., and rigging up machines for mass production of parts with great accuracy by unskilled labour, to act as Foreman-Manager of new small works, to employ about 30 hands, being erected near Brighton. £4 per week plus 10 per cent. profits. Must have had full rate as toolmaker, and been charge hand in a modern shop; also possess testimonials as to his skill and his capacity of getting output. Preference given to a keen young man not afraid of hard work, out for success first and last, able to keep expenses down and deal with all difficulties, demands and extortions of governmental bodies, and satisfy the officials. Knowledge of electricity and stove enamelling helpful, but not essential.—Address, A 679, Offices of ENGINEERING.

Estimating Mechanical DRAUGHTSMAN, at weekly rate of £3 16s. 9d., including Civil Service Bonus (at present 31s. 9d.); also MECHANICAL DRAUGHTSMAN, experienced, at weekly rate of £3 9s. 11d. including Civil Service Bonus (at present 20s. 11d.) required immediately. Applicants must be over 21 years of age.—Apply, by letter, to the COMMANDANT, Experimental Station, Porton, Nr. Salisbury. A 733

French Speaking MECHANICAL DRAUGHTSMAN WANTED
For position in Canada. Knowledge of engineering mathematics necessary as well as skill in drawing.
Address, with qualification particulars, A 609, Offices of ENGINEERING.

Wanted, Crane Draughts- MAN, accustomed to all types of steam and electric Cranes. Permanent position and good salary for suitable man, Leeds District. State age, experience and salary required.—Address, A 700, Offices of ENGINEERING.

Draughtsman Wanted, used to Elevating and Conveying Plants.—Apply, stating age, experience and salary required, to GOODALL, CLAYTON AND CO. LTD., Engineers, Hunslet, Leeds. A 715

Wanted, as Aircraft Draughtsmen, men with good engineering training. State age, wage, experience, and enclose references.—Address, A 745, Offices of ENGINEERING.

Wanted, Foreman, Experi- enced in the manufacture of high-class Balls for Ball Bearings. State experience and salary. First Class Man wanted.—Write, BOX 2851, WILLINGS, 20, King Street, Covent Garden, W.C.2. A 731

SITUATIONS WANTED.

Foundry Manager or Assistant Requires Position. Used to latest methods of Machine production, Ferrous and Non-Ferrous, speciality Motor work, excellent references.—E. B., 58, North Road, London, N.6. A 736

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THE STUDY OF INDUSTRIAL FATIGUE.

THE paper presented by Mr. D. R. Wilson to the Statistical Society on some recent work on industrial fatigue, with the lively discussion to which it gave rise, shows a sense alike of the importance of the subject and of the need for care in its treatment if the considerable pains and expense of the study is not to be wasted or even mischievous. In every operation of life there are acts of fundamental importance, such for example as breathing or balancing, that are done unconsciously. Some such acts are purely automatic, and some are the result of an acquired or secondary automatism; but however the body has got into the habit of doing them, these acts are done ordinarily without thought or conscious control, and if their action is stopped the organism may perish, or its efficiency may be gravely diminished. These acts are done because they are habitual, and experience has shown that they are not always done in the best way. In ordinary life they continue to be done in whatever wrong way may be habitual, until some observer of sufficient authority discovers the imperfection and succeeds in inducing people to alter it. Until then the habitual way, being taken unconsciously, is taken without question; and whatever inefficiency it may involve is tolerated as a matter of course, because no one is aware of the loss. That until recently has been the history of industrial work in this country.

The business of industry is to work, and among its most general and useful mechanical conceptions is that of energy, the power of doing work. Human energy is as important to industry as mechanical. The extent to which a worker can maintain himself and contribute his share to the support of his industry depends on the work he does. The industry on which he lives absorbs a vast amount of energy for its own bare upkeep, and the living it can yield him is in exact proportion to the work he does over and above what is absorbed in keeping the industry going. Much is said by persons who have the well-being of workers at heart of the need to provide them with a better life and a higher standard of living; above all, of preventing the standard of living from being degraded. The goodness of life and the standard of living are expressed in an infinite number of ways. The supply of material commodities, the extent of leisure, the amenities of work, its responsibilities, its dignity, are all invoked at one time or another as some ways in which the standard of life may be improved. Among those who are really concerned to give a fair deal to their fellow men there is no difference of opinion as to the aspiration that in all these ways, all men should live according to the best standard that is possible. The difference of opinion comes in when an attempt is made to ascertain what is possible, and this difference arises from the fact that often in their anxiety to secure for themselves or others the best possible life, men forget that this life has to be earned. Everyone wishes that all men should have whatever benefits life can yield; but every one does not always remember that he can have them only out of what, directly or indirectly, can be obtained from the earth and its fulness.

Accordingly it is of vital consequence to all workers that they should have constantly the largest possible power of work, and that this power should be used in the most effective way. This might not always be true if workers lived in individual solitude with Nature. If, for instance, they were placed on a tropical island, where the sun did much or most of their work for them, they might get on quite well with a poor extent and efficiency of work. Industrial countries, however, are not found in self-supporting tropical islands. They depend largely for their subsistence on what they get from other countries; and in exchange for what they get, the other countries give no more than what in the long run is its just equivalent. However the operation of the exchanges that regulate the subsistence of individuals may be complicated and disguised, it all comes back to the inexorable fact that the aggregate of mankind reap no more than they sow, and the conservation of human energy is as strictly a law of industry as the conservation of physical energy is of nature at large.

To obtain, therefore, the best possible living, men have to make the best possible use of their power to do work, and the necessity is the more evident because the power of each individual to do work is limited. Up to a certain point it grows with exercise, but beyond that point it falls off. This loss of energy through work, a loss of which the extent will vary not only with the duration but also with the conditions of work, is known as fatigue; and if it is not entirely recovered by rest, the individual has to earn his living out of less work. To such extent as the individual's living is confined to what he earns individually this means that he himself has to go short; but even if individuals can make good the shortage by raids on the living of others—the possibility and propriety of which are matters for ethics and politics, and do not come into the present discussion—they cannot make good the aggregate shortage of the community, or increase the total amount of commodities that it has to distribute.

The community and its individuals live, in fact, on their energy, and thrive according as they use it efficiently. Mr. Wilson's sketch of the history of what is called the industrial revolution and the events and movements that have succeeded it recalls how the industrial world has come gradually to learn that its energy has not always been used efficiently. Except in sporadic experiments, such as Mather and Platt's adoption of the 8-hour day in 1894, this fact has been realised slowly in this country, and was discovered and acted on a good deal earlier in the United States and Germany. Of late years, however, and especially during and since the war, this country also has begun to make inquiry into the way in which its human energy is being used, and one of the principal mechanisms of this inquiry is the Industrial Fatigue Research Board, of which Mr. Wilson is the secretary. The Board is barely five years old, and the inquiries of the Health of Munition Workers Committee, which it took over, date only two or three years further back. Its subject-matter is the knowledge of the relations of hours of labour and of other conditions of employment, including methods of work, to functions of the human body, having regard both to the preservation of health among the workers and to industrial efficiency; and in various branches of industry it has already shown reason for believing that in fact human energy in industry appears to be largely wasted.

As yet it has made little more than preliminary and tentative surveys of isolated parts of the field to be explored; but what it has already discovered has left it with the confirmed conviction that it has before it a task as important as it is difficult, and that as yet very little of it has been done. Perhaps to some extent the Board underrates what already has been done in the way of obtaining *prima facie* evidence of fatigue, and of facts indicating how it may be saved. In particular the work done in the United States long before the Board was formed or thought of had shown that in certain instances fatigue was being incurred when, for example, shortened hours or appropriate rest-pauses could avoid it, and had given ground for expecting that the measures which had been found successful in these instances might have a far more general application. The exposition and sometimes the methods of these most valuable and fundamental investigations left unfortunately a great deal to be desired, and it is intelligible, if regrettable, that a body such as the Board, composed mostly of distinguished scientific men, all of them amateurs in industry, should in allocating their already restricted financial resources have chosen not to undertake the cost of having a fresh examination made into these instances, and to prefer to start their own investigations *de novo*. The chief fault they had to find with the American work seems to have been that much of it was not conducted with the attention to the requirements of scientific method that was necessary to yield conclusive results. The same, indeed, might be said, and has repeatedly been said, of much work in this country, and the explanation apparently offered for this defect has been that industrial conditions permitted no closer accuracy. It is unnecessary at this date to inquire whether this explanation can be supported as applicable to the particular investigations in question; what is common ground is that in practically all investigations of the sort great care, experience and skill is required to enable the results to have the cogency of scientific conclusions. The facts of industry have in the last resort to be settled in industrial conditions, however much and helpfully laboratory investigation may have thrown preliminary light on them. These facts are of great complexity. Many of them cannot even be measured, and have to be assessed by the intuition that comes from practical experience, but even of those that can be recorded definitely the effect on the conclusions that are suggested by the results is not always clear, and the main purpose of Mr. Wilson's paper was to obtain the views of statisticians as to the extent to which results such as their investigations and those of the Health of Munition Workers' Committee had recorded, justified the conclusions that seemed to flow from them.

The inquiry indicates a sense of responsibility for conclusions announced by the Board which is gratifying to all whom these conclusions concern. It is the more gratifying because it has not always been as evident in published reports—particularly in those of the Munition Workers' Committee—as it is in Mr. Wilson's paper. Among the examples that Mr. Wilson, for instance, gives of work possessing exceptional merit are two which illustrate well the disadvantages under which the work has hitherto been carried out, even in elaborate and industrious inquiries into copious supplies of material. In one of these investigations, evidence was given to show that reduced working hours not only increased the hourly output of certain munitions, but often even the aggregate daily output. Instances to the same effect had indeed been recorded in earlier days, but the large scale of the observations recorded in this report made them undoubtedly a welcome addition to the available evidence. But unfortunately some of the figures showed more than the conclusions explained. The outputs, for example, were taken of the same workers during two periods respectively of 20 weeks and 11 weeks, in which different hours were worked, the second period not being counted until the output under the new hours had settled down to a steady weekly rate. The periods of observation seemed accordingly adequate, and so was the number of workers. Yet the remarkable result emerged that a gain of something over 14 per cent. in output followed on the reduction of the working hours by—0·6 hour per week. Here evidently some circumstance or group of circumstances was operating which, as it is not recorded in the report, was presumably not detected by the investigator; and the investigation was evidently incomplete and unsatisfactory until such circumstances—for there were others—had been sought and either discovered and defined or at least the significant failure to do so plainly indicated.

Similarly another report is quoted which announces the conclusion that speed of work is a more important factor than fatigue in causing accidents, because in an investigation extending over a period of two to three years and embracing an ample number of workers the curves of hourly incidence of accidents are said to have followed closely on those of output, but showed no correspondence with those of fatigue, as indicated by the hours for which work had been going on. Mr. Wilson invokes this observation in support of the conclusion of a laboratory investigation leading to a similar result, and undoubtedly is justified in seeking the co-operative weight of two wholly independent lines of inquiry. As a fact, however, the observational report is open to two objections that are fatal to its use for the purpose suggested. On the one hand a number of essential facts are supplied by estimate, and the estimates are made so crudely that their order of accuracy varies from less than 1 per cent. in respect of one correction—a precision that seems wholly outside what the material under observation could have yielded—up to a conjectural guess of $33\frac{1}{3}$ per cent.; the methods of computing output are highly speculative and inferential; and considerable explanation and adjustment has finally to be used to make the curves of accidents and output correspond. On the other hand, the matter of real interest is not the relation of speed in general to accidents, but the definition of the point at which increase of speed is followed by increase of accidents. Obviously, and by common experience, the accuracy of any set of motions

is increased by the concentration that follows an increase of speed up to a certain point, and the liability to accident, so far as it is due to the worker, is decreased; while increase of speed beyond that point reduces the time available for performing the motions below what is sufficient for doing them accurately, and thus increases the liability to accident. What is of real interest is to determine the critical speeds for given operations; and this the report makes no attempt to do.

In these instances, therefore, as in many others, a vast amount of material has been laboriously collected, and the investigation has nevertheless failed to yield the results that might have been hoped from it. The reports have not admitted the failure, presumably because they did not detect it; but the result of these and similar investigations has been that conclusions have been announced which on examination prove not to be established by the observations on which they were based. As Mr. Udny Yule remarked in the course of the discussion on Mr. Wilson's paper—and Mr. Yule is himself a member of the Board's Statistical Committee—results cannot be accepted as demonstrating a conclusion merely because they are compatible with it. Caution, moreover, as Mr. Yule also remarked, is particularly needed when the conclusion in question, if it was established, would be eminently gratifying to all concerned, and the hope of establishing it—such a conclusion, for instance, as that increased output could be obtained by doing less work—might be a powerful if unconscious influence in leading the investigator to find what he was looking for. That under proper conditions inferences may be drawn cogently and legitimately from experiments on individuals to results on whole industries, or contrariwise from mass observations to results on at least average individuals, cannot be questioned. The difficulty is to determine what are proper conditions.

This difficulty lies predominantly, as Mr. Wilson and other speakers realised, in the multiplex influence that affect most industrial operations. Perhaps the most plausible suggestion that has been made for avoiding it is that of Dr. Leonard Hill, who proposes that for experimental purposes purely industrial work shall be done by individuals in strictly laboratory conditions. How far that is possible will depend on the nature of the work, and at least the type of man suitable to be employed in such work may not be a fair sample of the average worker, nor the psychological conditions—interest, incentive and the like—the same as are found in workshops. Dr. Hill's interesting proposal in hands such as his own would doubtless, where it could be applied, yield physiological results applicable immediately to industry with greater accuracy and effect than they could be obtained otherwise; but they would still leave much to be determined that could be handled only in the full-scale works. As was pointed out recently in these columns in reviewing the Board's last Annual Report (see page 558, *ante*), any investigation of fatigue involves taking account of much that cannot be defined in general terms, and has to be put in by eye; and the whole value and authority of the result will depend essentially on whether the eye is genuinely and intuitively familiar with the conditions it has to assess. In Mr. Wilson's words, the Board's "investigators come to their task equipped only with laboratory technique"; and so long as this continues to be the fact its work will lose much of its possible value, especially in the various and often empirical conditions of the engineering trades. No one can question the advantage of having, so to speak, a caste of investigators, familiar with the methods that have been applied to the investigation of fatigue in all industries, and able to point out in the results of one industry facts that may be helpful to another. But the object of such investigators will be frustrated if it is not recognised that by themselves they are not competent to plan or carry out investigations that will be conclusive in engineering matters, deserve the confidence of engineers, or make anything like the full use of the material they obtain.

It is no disparagement of the work they can do in maintaining methodical continuity of investigations from one industry to another, in promoting the mutual helpfulness of results derived from different industries, in linking the facts to be investigated with the sciences, such as physiology and psychology, that have to be employed, or even in bringing to the inquiry a point of view that their very inexperience in the industry may sometimes make of advantage, to admit that their absence of first-hand industrial and technical experience must be made good in the planning and supervision of their inquiries, if they are to do for the engineering trades what is hoped and expected of them.

HARLAND AND WOLFF'S DIESEL ENGINE WORKS.

ONE of the most outstanding among the many interesting visits to works which are proposed for the coming summer meeting of the Institution of Mechanical Engineers at Glasgow is that to the Diesel Engine Works of Messrs. Harland and Wolff, at Finnieston. As an example of works design this establishment, which was constructed for the production of the Burmeister and Wain type of engine,* has much of interest for all engineers and works designers. The whole of the machinery installed was either chosen or specially designed for the repetitive manufacture of the standardised parts of the engines, and the lay-outs were arranged with the express intention of securing efficient and rapid production. On Plates XLI, XLII and XLIII, we give photographic illustrations of various parts of the works from which the general nature of the design may be clearly seen. As all machines are electric driven there is no overhead shafting. Travelling cranes in each bay and small jib cranes mounted on the columns for handling the castings and finished work at the machines are the only overhead equipment.

The three-phase electricity supply at 6,500 volts of the Glasgow Corporation is transformed into a direct-current supply in a sub-station containing transformers and three rotary converters. Two of the converters are of 750 kw. capacity and the other is of 250 kw. From this sub-station, which is built on to the end of the engine machine shop, electricity is distributed on the three-wire system, with 250 volts between each outer and the neutral. The cables are generally taken overhead to the various sections of each shop and are also carried overhead between the different workshops. In one of the main aisles of the engine machine shops there is, however, a covered duct in the floor which carries some of the cables.

The works consist of three separate buildings. In the first are the general fitting, erecting and testing shops. The second contains the heavier plant for engine machine work, and the third is devoted to casting stores, brass foundry, copper shop, sheet iron department, tool rooms and the manufacture of crankshafts and thrust and tunnel blocks.

The fitting, erecting and testing shop is divided up into six bays, each of which is equipped with overhead electric and jib cranes. The parts made in the many different sections of the works are constructed to stores order and are brought together in this shop for assembly and test. Each part of a bay is devoted to the erection of some particular detail in the engine. In the first bay, fuel valves, fuel pumps, air starting valves, camshafts and governor gears are dealt with. These parts are the smallest of the important detail components. The next bay is given over to the fitting up of the medium type of work such as the inlet and exhaust valve boxes, cylinder covers, connecting rods, piston rods, crossheads and guides. In Bay 3 the parts of the manœuvring compressors are brought together and erected. When they are completed they are put through a series of tests on the erection beds. The pressure air compressors, which supply the blast air to the engines, are also erected in this section before their transfer for fitting up with the engines.

All the auxiliary and emergency lighting sets required are erected in Bay 4 and after assembly are tested within the same bay. The necessary electrical testing devices and apparatus are fitted up between the columns. To the left-hand side of the view in Fig. 2, Plate XLI, the top end of this bay is shown, where the assembly of some auxiliary sets is in progress. The last two bays, numbers 5 and 6, are reserved for the erection and testing of the large marine and stationary engines. The top ends of these two bays where the testing is carried out are also shown in Fig. 2. Heenan and Froude water brakes are used to load the engines during the course of their trials.

This shop is situated close to the Finnieston Quay, from which the engines may be shipped for export or installed on board with the use of the harbour crane. A rail connection runs from the test beds to the crane, a distance of only 250 yards, and special rolling-stock, including a flat-decked electric tractor is provided for carrying the heavy loads.

The main engine shops are situated on the opposite side of Lancefield-street from the erecting shops and are divided into three large bays, numbered 7, 8 and 9. Three of the illustrations, Fig. 4, on Plate XLII, 5 and 6 on Plate XLIII, show views in this part of the works. Here again are to be found heavy overhead cranes in each bay and small jib cranes erected on the columns. At the end of Bay 7, which contains the heavy machines, there is an imposing milling machine which is used to machine the engine bed plates. It is capable of taking work up to 15 ft. high and has a travel of about 50 ft. The engine bed plates are mounted with the top face vertical by bolting them to heavy triangular cast frames with suitable spacing pieces interposed. Another conspicuous machine in this bay is a radial drill which has a swing of 11 ft. The middle bay is illustrated in Fig. 5, Plate XLIII. It is divided into two sections, in the first of which planing, boring and facing work of medium weight is performed, while the second section is principally a vertical boring department with machines capable of work up to 2 ft. diameter in the smallest units to 10 ft. diameter in the largest. Between the two parts of the equipment of this bay are situated the water test plants. Here all parts dealt with in the bay are subjected to hydraulic pressures to eliminate all possibility of anything faulty in material or construction getting through to the erecting shop. Bay 9 may be considered as composed of seven different parts, according to the various classes of work undertaken. The general view Fig. 6, Plate XLIII, shows a large group of centre lathes in the foreground. There are also in this end of the works groups of drilling machines, various types of milling machines and turret lathes. A section of the bay is given over to bar work in capstan and turret lathes. There is also a special plant for thread milling large studs and bolts and machines for tapping and facing large nuts. The next group of machines was put down for the making of piston rings and cams and for the performance of cylindrical grinding work. Automatic machines in which large quantities of bar and chuck work are performed complete the equipment of this section.

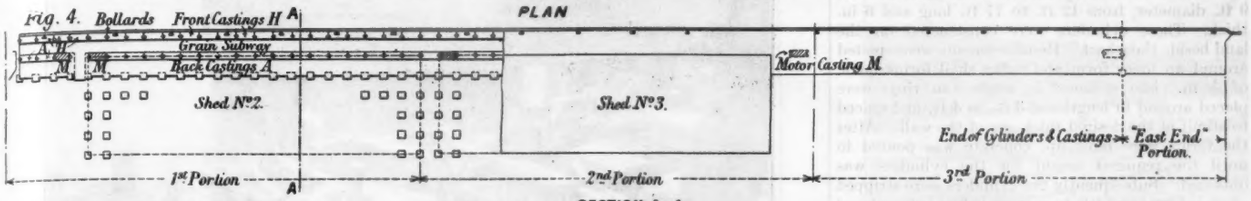
The third workshop is divided into three bays. The main entrance is at one end of the first bay, and in this part of the works there is a rough castings store. Leading off from this section are the copper shop, the smithy, the brass foundry and the sheet iron department. At the top end and extending across the next bay there is a manufacturing toolroom where the jigs and tools are made. A spring-making department is also included in this area. The second bay is equipped for the machining of all miscellaneous fittings and for the building up of coolers for lubricating oil and water. The first part of the next bay is devoted to the machining and fitting up of stern tubes, their bushes and tailshaft liners. The jig and tool store is situated at the one end of this section, and at the other end the rotary pumps for lubricating and fuel oils and also water pumps are fitted up and tested. The test bed for the application of water pressures to the various parts is located in the middle of the shop. The next bay is equipped for the complete machining and assembly of thrust and tunnel blocks. Large crank shafts are built up and turned in the next section, which is followed by another for the smaller crankshafts of auxiliary sets and air compressors.

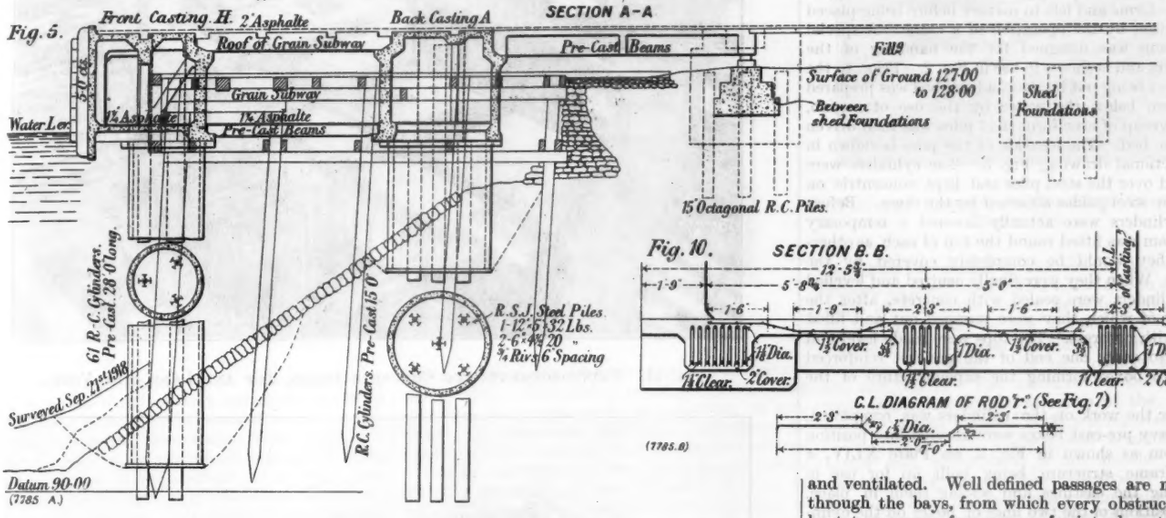
The works are all lofty, well lighted, heated

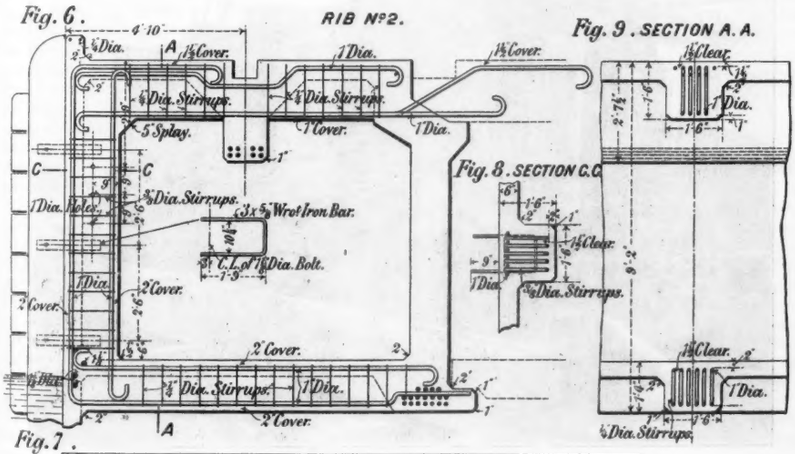
* See ENGINEERING, vol. cix, page 12.

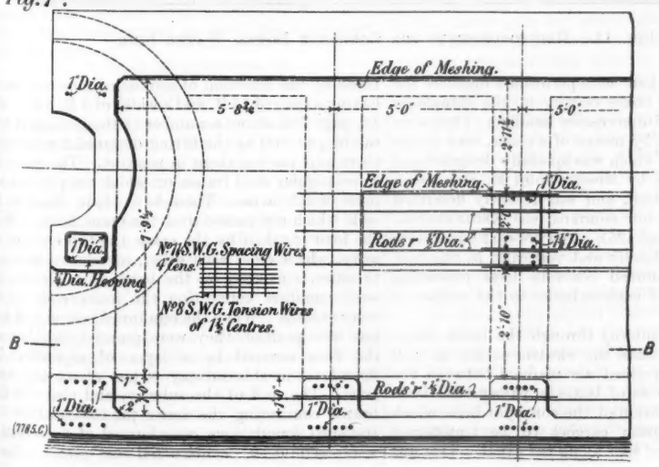
THE TRAFFORD WHARF ON THE MANCHESTER SHIP CANAL.

MR. H. A. REED, M.INST.C.E., ENGINEER; MESSRS. KIRK AND RANDALL, LIMITED, CONTRACTORS.









THE TRAFFORD WHARF ON THE MANCHESTER SHIP CANAL.

ECONOMIC considerations enter so largely into every present-day activity that it is not surprising to find the application of entirely new methods in constructional work, which are calculated to reduce the total cost of the enterprise. As only essential work can be carried out when prices are high any improvements in methods with the consequent reductions in costs may result in a great increase in the amount of work which may be attempted. As one example of the changed attitude of engineers and contractors towards design and construction the new Trafford Wharf on the Manchester Ship Canal may be cited. The works are situated on the south side of the canal and were carried out in accordance with the designs of Mr. H. A. Reed, the chief engineer to the Canal Company. In the actual work the contractors, Messrs. Kirk and Randall, Limited, of Grosvenor-road, London, introduced many innovations for the purpose of obtaining a sound and substantial structure at the minimum of cost. The features of interest in the construction were the use of pre-cast cylinders and boxes of reinforced concrete, and the methods of handling them and placing them in position.

The actual work consisted of building a reinforced concrete wharf facing, and parallel to the direction of the canal with foundations for warehouses extending to the railway lines between the canal and Trafford-road. The illustrations on Plate XLIV, published with this issue, on the present page and on pages 704 and 705, show drawings of the design and photographs taken during the progress of the work.

The wharf was built up of a double length of pre-cast reinforced concrete boxes mounted on two rows of reinforced concrete cylinders bedded in the slope of the bank and resting upon the canal bed. A photographic view of the entire construction just prior to its completion is shown in Fig. 1, Plate XLIV, while the plan Fig. 4, annexed, shows the and ventilated. Well defined passages are marked through the bays, from which every obstruction is kept to ensure a free passage for interdepartmental traction by electric trucks. Supervision and control within the works has been greatly simplified by the arrangement of the lay-out.

location of the cylinders and the line of concrete boxes as well as foundations for the sheds.

The cylinders in the outer line are of 6 ft. 6 in. diameter and approximately 28 ft. length with a thickness of wall of 4½ in., while the inner row are 9 ft. diameter, from 12 ft. to 17 ft. long and 6 in. thick. These cylinders were constructed on the land beside the wharf. Reinforcements were erected around an inner form and outer shell forms made of ⅜ in. plate stiffened by angle iron rings were placed around in lengths of 3 ft. to 4 ft. and spaced to admit of the desired thickness of the wall. After the forms were built up, concrete was poured in until the required height for the cylinders was obtained. Subsequently the cylinders were stripped of their forms and left to mature before being placed in position by the operation of a crane. A special steel ring was designed for the handling of the cylinders and is shown in use in Fig. 2. Prior to the cylinders being put in place, a level bed was prepared for them below the water by the use of a grab, and a group of cruciform steel piles was then driven into the bed. The location of the piles is shown in the sectional drawing, Fig. 5. The cylinders were lowered over the steel piles and kept concentric on them by steel guides attached by the diver. Before the cylinders were actually lowered a temporary steel dam was fitted round the top of each, as otherwise they would be completely covered by the water. When they were finally centred and levelled the cylinders were sealed with concrete, after the setting of which they were pumped out and filled solid with concrete. The tops were made level and ready to carry one end of the pre-cast reinforced concrete boxes forming the superstructure of the wharf.

After the work on the cylinders was completed, the heavy pre-cast boxes were lowered into position on them as shown in Fig. 3, on Plate XLIV, a steel frame structure being built up for use in handling the castings and setting them in place. The positions of the two lines of boxes on the cylinders is shown on the general plan, Fig. 4, page 703, and their shapes and the forms and sizes of the steel members incorporated in their construction are shown in the drawings, Figs. 5 to 10. Photographic illustrations at three successive stages in the operation of building them up are provided in Figs. 11, 12 and 13. The boxes have internal ribs and stiffeners to provide the requisite stress-resisting properties. The reinforcements were bent to form and erected around "Blaw" forms in the manner clearly shown in Figs. 11 and 12. The former of the two illustrations is a view from above, and shows the projection of some of the steel bars on the land side of the structure. These were later cast into other concrete work connecting the boxes. The view in Fig. 12 shows the relationship of the steel members for the water side of the boxes. When everything was completed the outer forms were built up, leaving the width necessary for the concrete. Fig. 13 page 705, shows the final stage in the work prior to casting.

The concrete used had an aggregate of Welsh granite broken to pass through a ¾-in. mesh and Mersey sand, and was mixed by two concrete mixers, each having a capacity of ½ cub. yard and driven by a petrol engine. An Insley tower mounted upon rails and of sufficient height to command the full width of the works was used to distribute the concrete. The tower was built on the works to the designs of Messrs. Christmas, Hulbert and Walters, Limited, of Caxton House, Westminster, who were also responsible for the design of the steel "Blaw" forms, which were imported from Pittsburgh, U.S.A. The Insley tower was served by a travelling jib crane which transferred the materials from railway wagons to the receiving hoppers from which it was passed to the mixers by gravity. A long chute swung from a hinged arm or jib directed the concrete to the work. This chute could be swept round with a radius of 90 ft. and thus was sufficient to serve the outside line of cylinders.

After the concrete boxes had been left to mature for some time they were stripped of their internal and external "Blaw" forms and were left on their timber bases until they were placed in permanent position upon the cylinders, The boxes are 25 ft. long, 11 ft. wide and 9 ft. high. Each of the outside boxes weigh 63 tons and the inside ones 58 tons.

THE TRAFFORD WHARF; MANCHESTER SHIP CANAL.

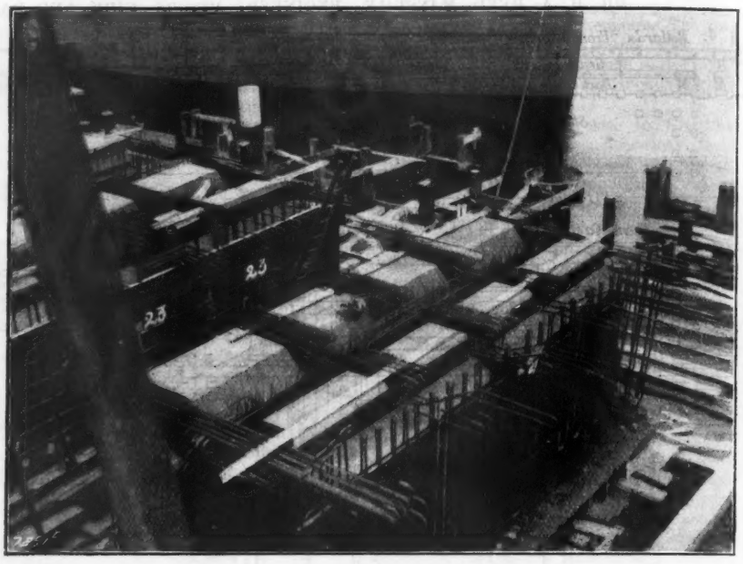


FIG. 11. REINFORCEMENTS FOR CONCRETE BOXES, TOP AND LAND SIDE VIEW.

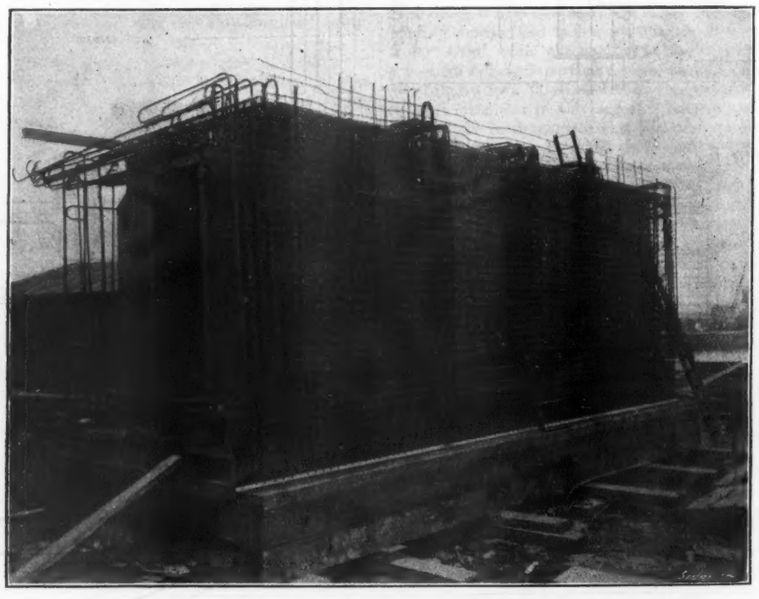


FIG. 12. REINFORCEMENTS FOR CONCRETE BOXES, WATER SIDE.

The casting operations were performed opposite the positions that the boxes occupy in the completed wharf to obviate all unnecessary handling. They were lifted into position by means of a crane, seen in the distance in Fig. 1, which was specially designed and built for the work by Messrs. John M. Henderson and Co., of Aberdeen, and was recently described and illustrated in our columns (see ENGINEERING, present volume, page 425). The pre-cast boxes were connected longitudinally and vertically to the base cylinders by reinforced concrete keys extending from the interior of each cylinder to the surface of the wharf.

The continuous subway through the outer structure will accommodate the electric cables, as well as water and compressed air mains. Between the outer and inner rows of boxes a passage was built for the accommodation of the conveyor belts which will enable the grain cargoes to be transferred to the elevators and silos along the canal. This was made by the insertion of reinforced concrete beams having a span of 15 ft. and a width of 3 ft. 8 in. Fig. 14, page 705, shows a number of these stacked after casting, as well as the fitting designed for handling them and placing them in position. This grab has a rectangular steel frame, on which are pivoted two pairs of side arms. These have chain slings at the ends which are passed over the crane hook. When the load is taken by the crane the top ends of the arms, which cross each other, are drawn in and a pressure is exerted on the beam through the side steel members connecting the lower ends of the lever system. When the reinforced beams had been put into position they were grouted together and the floor covered by a layer of asphalte. The floor level in this subway is just above the water level. The roof of the subway, and also the floor beams connecting the inner pre-cast members to the shed foundations, was formed of a corrugated reinforced deck, constructed on steel "Blaw"

THE TRAFFORD WHARF ON THE MANCHESTER SHIP CANAL.

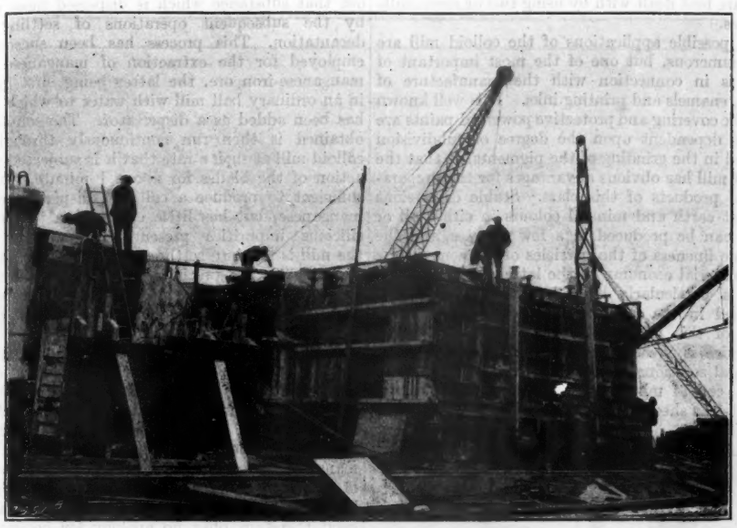


FIG. 13. EXTERNAL FORMS BUILT UP AROUND THE REINFORCEMENTS.

FIG. 14. REINFORCED CONCRETE BEAMS AND LIFTING GRAB.

forms, 100 ft. in length, which were designed to travel along the length of the wharf as the shuttering was removed after the concrete had set.

When completed, four transit sheds with five floors will abut upon the wharf, the fronts being actually carried by the wharf. The shed floor beams will be carried on the landward side upon the shed foundations. The floor of the first bay of the sheds will consist of the reinforced concrete beams bridging from the inner row of pre-cast boxes and the front row of the foundation blocks. In the spaces between the sheds the beams will be continued to form the wharf decking. The foundation blocks for the sheds will be carried upon groups of reinforced concrete piles, with steel spirals and vertical rods, fitted with chilled cast-iron shoes. Octagonal in form, the piles are 15 in. across the flats and from 33 ft. to 40 ft. in length. They have about 21 lb. of steel per cubic foot of concrete. A floor for the construction of these piles was specially prepared on a site beside the works, which was equipped with a concrete mixer and traveller for distributing the concrete to the pile moulds. An appliance was designed to facilitate handling these long piles, in which they were gripped by wedges in a frame made of rolled steel sections, and could be lifted without any danger of damage. These piles were then driven into the ground until their tops were about 6 ft. below the surface, and the reinforcements of the heads were bared to connect up with the concrete base. Within the excavation a steel "Blaw" form was erected, and after it was trued up to line and level, it was filled with concrete from the Insley tower to form the foundation for the warehouse.

THE COLLOID MILL.

UNTIL comparatively recently such developments as have taken place in the application of colloidal chemistry to industrial processes have been made mainly on the Continent, and particularly in Germany, but now that increased attention is being given to the subject in this country and its importance is becoming more generally realised, it seems probable that the use of this branch of chemistry in British industries will extend more rapidly than has hitherto been the case. Many modern industrial processes involve the preparation of what are known as colloidal dispersions of solid materials in liquids, or of one liquid in another, and it is mainly with the production of such dispersions on a commercial scale that we now propose to deal.

Colloidal dispersions may be said to occupy an intermediate position between simple mechanical suspensions, such for example as sand in running water, and true molecular solutions such as common salt in water. The solid or liquid particles of some substance in an extremely minute state of subdivision are uniformly distributed throughout the liquid dispersion medium and they can be retained in solution indefinitely, if desired, although they are not in molecular solution. Faraday, it may be remembered, produced a colloidal dispersion of metallic gold in water, and the resultant pink-coloured, transparent liquid, we believe, is still in existence in the archives of the Royal Institution, where it has remained unaltered for upwards of sixty years. The lubricating materials well-known to engineers as Aquadag and Oildag are also examples of colloidal dispersions of graphite in water and oil, respectively.

The dimensions of the particles in colloidal dispersions are such that they are not visible in an ordinary microscope and cannot be separated by simple filtration. Their presence, however, can be detected by means of the ultra microscope, and filtration can be effected on a small scale by a filter consisting of a film of collodion; filtration on a commercial scale can be carried out in the Plauson ultra filter press, with which we are not concerned at the moment. The particles actually range from about 10 $\mu\mu$ to 100 $\mu\mu$ (1 $\mu\mu$ = 0·000001 mm.) in diameter, and when it is pointed out that the practical limit to the fine grinding processes in common use is reached by the production of particles about 0·008 mm. in diameter, which is 80 times the diameter of the largest particles in colloidal dispersions, it will be seen that the production of the latter calls for quite different processes.

Particles of colloidal dimensions can be produced from true molecular solutions, the condensation of the molecules being effected by chemical means. A metal, for instance, can be reduced from the solution of a metallic salt, and this was the method used by Faraday for the production of the colloidal gold above referred to. On the other hand, similar results can be produced by starting with comparatively coarse particles and effecting the necessary comminution by physical or mechanical means. Cathodic disintegration is an example of a physical method of bringing about the minute subdivision of a metal. The action of heat may also be employed with other materials using suitable dispersion media. The purely mechanical dispersion of solid materials in liquid media for the production of colloidal solutions on a commercial scale, we believe, was first rendered possible by the invention of the colloid mill by Hermann Plauson some fifteen years ago. We have already referred to the Plauson mill and some of its industrial applications on page 429 of our 110th volume, but as the mill has now been placed on the market in this country it may be of interest to describe its construction and to deal with some of the more recent developments. For a general discussion on the physics and chemistry of colloids and their bearing upon industrial problems, however, we would refer our readers to pages 580 and 595 of "ENGINEERING" vol. cx, where a joint discussion by the members of the Faraday Society and the Physical Society is reported.

In principle, the Plauson mill is similar to a beater mill, although it is not suitable for dry grinding. Plauson, in fact, discovered that by grinding a solid material with a comparatively large proportion of liquid and rotating the beaters at a high speed, a very much finer state of subdivision of the solid could be brought about than was possible by any method of dry grinding. The results, however, are greatly affected by the peripheral velocity of the beaters, a velocity of about 40 m. per second being necessary for the production of colloidal dispersions. When the velocity is reduced to 20 m. per second, the smallest particles produced have a diameter of about 0·003 mm., while at 10 m. per second, their dimensions do not differ materially from those produced by dry grinding. The actual disruption of the particles in the colloid mill appears to be mainly due to the fact that intense local pressures and shearing stresses are produced in the thin layer of liquid caught between the rapidly rotating beaters and the adjacent stationary parts, the pressures and stresses being transmitted to the solid particles in suspension in the liquid. The nature of the latter, however, is of considerable importance. Some materials which can be dispersed in water can be more rapidly and effectively dispersed in organic media. For instance, the usual paint pigments can be most easily dispersed in linseed oil. Another point of importance in this connection is that certain substances, even when added in extremely small quantities to the mixture of material to be dispersed and the dispersion medium, have the effect of accelerating the action to a remarkable extent. Such dispersators, as they are called, are in common use in many grinding processes, their effect being to prevent the re-aggregation of the particles already separated by mechanical means. The electrical charges carried by the particles or molecules of the various materials also affect the results, but we do not propose to consider their action here.

The actual construction of the Plauson mill, which is designed and supplied by Messrs. Plauson's Mill and Filter Press, Limited, Seymour House, 17, Waterloo-place, London, can be readily followed by reference to the illustration on page 706, which shows the mill with the front cover removed. As will be seen, the body of the mill is in the form of a short cylindrical casing which is made from a close-grained cast iron having a high resistance to corrosion. One end is normally closed by a cover held in position by studs. The cover,

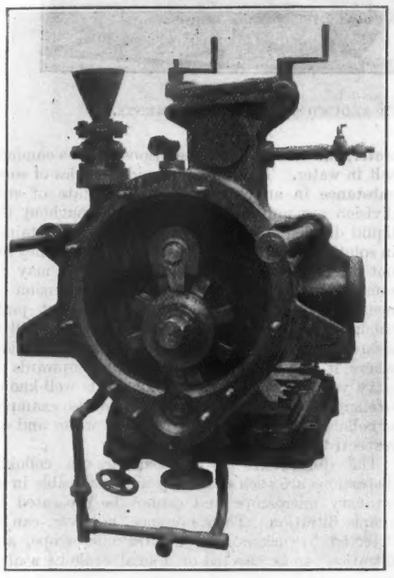
however, can easily be removed to enable the interior to be inspected and cleaned, and during this operation it is supported by rollers running on the two long bolts, which can be seen in the illustration projecting horizontally from the body. Both the cover and the body walls are made hollow to enable them to be heated by steam, or cooled by the circulation of water, and the pipe connections for the supply of steam or water to the jacket spaces are clearly visible in the illustration. The other connections shown are a filling branch fitted with a funnel and plug cock in the top left-hand corner, a charge hole for solids situated on the right-hand side and fitted with a hinged cover, an outlet branch with a stop valve at the bottom, and a flanged connection on the right-hand side to enable a number of mills to be operated in series, as will be explained later. The small pipe connection with a cock on the right-hand side of the charge hole is provided to enable the air in the mill to be displaced by any other gas when necessary.

Arranged eccentrically in the lower part of the body of the mill is a revolving beater consisting of three steel discs, each formed with eight radial arms or blades. The discs are keyed on to a shaft with distance pieces between them, and are arranged so that when the shaft is rotated the blades pass through the corresponding spaces left between two sets of four stationary blades; the width of the clearance space between the moving and stationary blades is about 1 mm. The stationary blades are fixed to the body of the mill, so that they project radially inwards towards the axis of the beater in the positions clearly shown in the illustration. The beater shaft passes through a stuffing-box in the rear end of the body of the mill and runs in ball bearings housed in two pedestals, which are mounted on a cast-iron baseplate. The shaft is driven by belt at 3,000 r.p.m. from an electric motor developing from 7 h.p. to 20 h.p. according to the particular service for which the mill is required; about 8 h.p., however, is sufficient to drive the mill in most cases. The body of the mill, it should be mentioned, is secured by studs to a flange formed on one of the pedestal bearings, and is further supported from the floor on the brackets shown on both sides of the illustration.

From the foregoing description, it will be seen that the construction of the mill is simple and straightforward, but it will also be obvious that the high speed and small clearances employed call for careful balancing of the rotating parts as well as for the employment of high-class materials and workmanship; the mills are manufactured in this country by Messrs. Mather and Platt, Limited, Manchester. It should, perhaps, be pointed out that the eccentric mounting of the rotating blades relatively to the body of the mill is an important feature of the design, since it produces a constant circulation of the material under treatment. A continuous supply of fresh particles of suspended matter is thus passed through the narrow clearance spaces between the fixed and moving blades, in which spaces the whole of the grinding action is concentrated. Moreover, as previously mentioned, the disruption of the particles results mainly from the impact of the rotating blades on the liquid in the clearance spaces, and from this it will be evident that, for a given expenditure of energy, a certain number of heavy blows will be more effective than a greater number of lighter blows. For this reason only two sets of fixed blades have been employed, this number being necessary to balance the resistance torque.

The mill takes a charge of 3·3 gallons of liquid, but its productive capacity, of course, depends upon the time required for the complete dispersal of the charge and varies with the material under treatment. As an example of its capacity we may mention that a charge of 30 lb. of oxide of iron and 20 lb. of linseed oil can be ground into superfine paint in 8½ minutes. It is, of course, possible to treat single batches of materials independently in this way, but in order to eliminate the time occupied in charging and emptying the mill, the usual practice is to arrange the plant for continuous working. The raw materials, in suitable proportions, are fed into the mill continuously, the rate of flow being adjusted so that the time occupied by the materials in passing through the mill is just sufficient to ensure complete dispersal. With materials requiring prolonged treatment, the rate of flow through a single mill would be inconveniently low, and such cases are best dealt with by using two or more mills in series.

The possible applications of the colloid mill are very numerous, but one of the most important of them is in connection with the manufacture of paints, enamels and printing inks. It is well known that the covering and protective powers of paints are largely dependent upon the degree of subdivision reached in the grinding of the pigments, so that the colloid mill has obvious advantages for the preparation of products of this class. Stable dispersions of most earth and mineral colours in either oil or water can be produced in a few minutes, and the extreme fineness of the particles of pigment results in a material economy in the latter. With carbon black a particularly high degree of dispersion is obtained in the colloid mill, and the commercial value of this material in the rubber and other industries is greatly increased by the treatment. Colloidal solutions of sulphur can also be prepared in the colloid mill for use in the rubber industry, and also as sheep dip and fungicides in agriculture.



It is also possible to disperse certain insoluble organic dyes, such as indigo, so finely that they can be used for dyeing fibres without any other preparation. Resin, pitch and waxes can also be dispersed in water for certain industrial purposes.

For the production of emulsions or colloidal dispersions of one liquid in another, the Plauson mill is particularly well adapted. Cutting oils can be made very effectively by its aid, and essential oils can be dispersed in water for the production of perfumes, flavouring essences, &c., instead of dissolving them in alcohol, as is usually done. Frequently also, chemical reactions between substances which are comparatively inert, or the solution of substances otherwise only soluble with difficulty, can be greatly expedited by the intimate admixture which results from grinding them together in the colloid mill. Some oils, for instance, which can only be saponified by prolonged boiling with alkali can be rapidly saponified if ground in the mill together with the necessary alkali. The saponification phase of soap manufacture has been carried out at the rate of 1,350 lb. per hour in one mill.

The only other application of the mill with which we propose to deal on the present occasion is in connection with the refining of solid materials, its use for this purpose being illustrated by an example selected from the various possible applications in the metallurgical industries. The refining process depends upon the fact that colloidal dispersions can be made much more readily from some substances than from others, so that by treating a mixture of two or more substances in the colloid mill for a certain period, it is possible to separate out that substance which is dispersed most easily by the subsequent operations of settling and decantation. This process has been successfully employed for the extraction of manganese from manganese-iron ore, the latter being first ground in an ordinary ball mill with water to which alkali has been added as a dispersator. The solution so obtained is then run continuously through the colloid mill at such a rate that it is subjected to the action of the blades for about 1 minute, which is sufficient to produce a colloidal dispersion of the manganese, but has little effect upon the iron or silicious impurities present. The effluent from the mill is run into settling tanks in which the iron and silicates are precipitated, but the manganese, being in the colloidal state, remains in suspension and the solution is subsequently dewatered by the usual processes.

It is, perhaps, hardly necessary to add, in conclusion, that the above-mentioned applications of the colloid mill by no means exhaust its possibilities. They will, however, suffice to indicate the class of work for which it has already been employed and will therefore be of service to those engaged in the manufacture of similar products. Improvements of this type in industrial processes are of considerable interest and importance to engineers, and we need therefore offer no apology for having dealt with the subject at some length.

NOTES ON NEW BOOKS.

IN his German treatise of 1777, on "Chemical Affinity," Wenzel clearly recognised that a reaction between two bodies does not entirely proceed in one direction, but stops at a certain equilibrium point. Theoretical chemistry developed in many ways; Guldberg and Waage enumerated their law of mass action in 1867. But it was not till 1877 that Willard Gibbs gave, in his Phase Rule, a general theory of chemical equibria on a thermodynamical basis, and this in so strictly mathematical a garb that the rule, like some of its incomplete anticipations, had to be unearthed again. At present the phase rule is applied to almost any reaction in which substances, either as such or in mixtures or solutions, may exist in the solid, liquid or gaseous phases, and to all processes of solution, fusion, evaporation, crystallisation and condensation. The domain is constantly growing, and we have the fifth edition of Dr. Alexander Findlay's "*Phase Rule and Its Applications*" (London: Longmans, Green and Co.; price 10*s.* 6*d.* net) before us. Dr. Findlay, who is professor of chemistry at the University of Aberdeen, originally brought out this work in 1903. The latest edition, though apparently not larger than the fourth, has been reset and largely rewritten. The graphic representation method for systems of four components, which Jänecke proposed more than ten years ago, is for the first time adopted. As regards the iron-carbon diagram Dr. Findlay possibly dismisses the β modification too readily; but some of the recent evidence *pro* and *contra* apparently came too late for him. The section on Liquid Crystals is disappointingly short. The copious literature references will increase the value of the volume to the specialist.

The commodities in everyday use concerning which little is known by the general public, are exceedingly numerous, and this probably applies to mineral products more than to those of the other kingdoms. For this reason, a book dealing with nickel, its discovery at an early age and re-discovery at a comparatively late period, its occurrence in nature, treatment and uses, will supply the insufficiency in respect to one metal. The book is entitled "*Nickel*," and forms part of the Pitman's series on Common Commodities and Industries. Stress is laid upon the advantages surrounding the use of nickel for coins of relatively low value, and also for cooking utensils. For the latter, however, it would seem to us that aluminium, the excellent qualities of which are difficult to beat, and are not known as they should be, is the better of the two metals. The book refers to the very successful work carried out in the early eighties of last century in France by Messrs. Schneider and Co., in the manufacture of nickel-steel armour plates. It is edited by Mr. F. B. Howard White, and is published at the price of 3*s.* net by Messrs. Sir Isaac Pitman and Sons, Limited, Parker Street, Kingsway, W.C.2.

To all manufacturers of power station machinery and equipment, electrical fittings, cables, and indeed

ROAD MATERIAL PREPARING PLANT.

(*For Description, see Page* 708.)

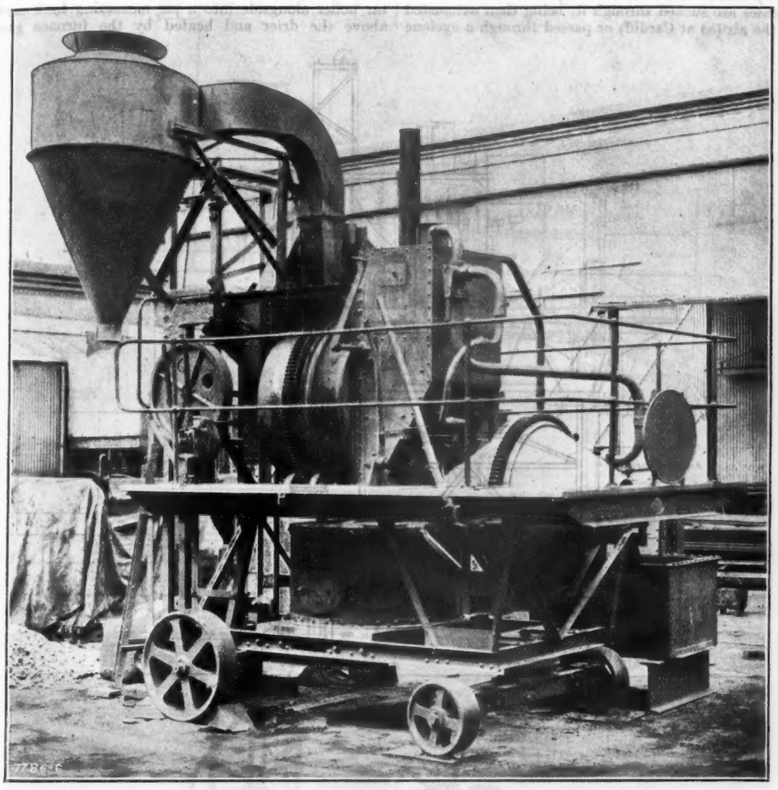


FIG. 10. 7-CUB.-FT. PORTABLE TAR MACADAM DRYING AND MIXING PLANT; MESSRS. STOTHERT AND PITT, LIMITED.

of electrical apparatus generally, a knowledge of the conditions of the electricity supply of towns which may interest them from a business point of view is very important. No work with which we are acquainted provides the information in a more useful and succinct form than the "*Electrician*" annual tables of electricity undertakings (London: Benn Brothers, Limited. Price 10*s.* net). In the thirty-sixth edition of this compilation, the reader will find the leading particulars of practically every power station in Great Britain and the Dominions, and also of a large number of foreign undertakings. Typical information includes the population of the place, the names of the owners and of the Engineer, the voltage frequency and nature of the current, the equipment of the generating station, the fuel used, the maximum load, the total connections and the prices charged. Exclusive of the large Power Companies whose undertakings receive special treatment, 630 British, 451 Colonial and 261 Foreign undertakings are dealt with on the lines we have indicated, while briefer particulars are given in respect of scores of other towns. It is depressing but instructive to compare the size of the average British station with that serving an equal population abroad, but by reversing the comparison an idea can be formed of the magnitude of the foreign market awaiting the enterprise of our manufacturers.

The Finance Act of 1922 provided for the revaluation of all property in the United Kingdom. London is outside the scope of this scheme, as it is governed under its own special Act providing for revaluation every five years. Normally a revision has taken place quinquennially everywhere, except during the period of the last twenty years. In that interval the first interruption was due to the excessive work in valuation entailed in carrying out the provisions of the Lloyd-Georgian Budget of 1909–10, and the later ones due to the reduction of available staff during the European War. It must be noted that there is no specific provision for the revaluation of property outside London every five years, but that action has become customary. Recently there has arisen a great controversy regarding the revaluation, and the public interest in the question has been enormously increased. We cannot here deal with such matters as those under discussion by the public, but there are many readers of ENGINEERING who will have to study the question in regard not only to house property, but to works and factories, and the machinery they contain. In view of this the publication is to be welcomed of an exhaustive work on the subject by Mr. J. Stanton. The title of the book is "*Schedule A and House Duty Assessments*," and it is published by the author, 12, King's Bench Walk, Temple, London, at a price of 1*l.* 7*s.* 6*d.* net. In it is to be found a complete examination of the whole subject in all its many aspects, and the decisions in test cases are given for the information of the reader. As appeal by the taxpayers has been already admitted, many people, when they receive their assessments for 1923–24, will want to know their position. This work will prove of immense value to them in deciding whether the Inland Revenue officials are acting reasonably, or whether they have omitted to allow for matters on which there have already been decisions in test cases.

Books on colour will appeal to a wide circle of readers, but the readers will expect treatment according to their individual interests. Dr. L. C. Martin and Mr. W. Gamble hope that their "*Colours and Methods of Colour Production*" (Blackie & Sons, Limited, price 12*s.* 6*d.* net) will be of use to those dealing with colour in the worlds of commerce and art, and that the book will also stimulate the interest of people of a scientific training. Dr. Martin's divisions are suggestive of these objects. Part I aims at giving a simple account of the theory of colour measurement: Part II is to provide an introduction to the more advanced study of colour measurement and colour vision: Part III, contributed by Mr. William Gamble, deals with colour printing and with colour photography, in 21 pages out of a total of 187 pages. These last two chapters, good as far as they go, are inadequate, and the general reader, who might find some of the sections on instruments for colour measurements and on colour vision too technical, may be disappointed in other respects; not, we think, because the theory of light is excluded, and fluorescence is dismissed with a few lines. But what is the reader to learn from the definition of colour: "Colour is a term given to the sensations due to those qualities of the light by which an eye may recognise the form and nature of an object." Uniform colour does not help us in recognising form. Dr. Martin might, perhaps, have started with his second definition: "White is the colour of sunlight passing through a minimum thickness of the earth's clear atmosphere." But the definitions would not become much more instructive. On page 16 we find a very good coloured plate illustrating additive and subtractive colour mixtures; only additive colours are explained, however, and the subsequent notes (on page 27) on subtractive colour-mixing are unsatisfactory. In the chapters on colour notation prominence is given to Munsell's colour system, while Ostwald's system is not mentioned at all. The originators of many of the spectral curves given are not stated. The Purkinge phenomenon is mentioned several times, but not definitely specified. The volume has its good points, but we feel uncertain as to the class of readers it will please.

Many practical workers find the longer and exhaustive text books, on the various subjects comprised in engineering, are so elaborate as only to provide them with the information they want after a diligent and time-absorbing search. The number of people who require general works with a thorough treatment of any section of engineering science is, of course, large, but that number is still only a fraction of those who wish to use their text books in dealing with the consideration of any difficulty that arises in their work. For such workers nothing very elaborate is required, but the practical applications of every principle that is enunciated must be clearly demonstrated. The difficulty encountered by authors in dealing with such books is in deciding what must be included and what may reasonably be left out. After all every man has his peculiar and individual needs, and if he hopes to find them met in a single work it must be more extensive than his requirements, for it must meet the wants of others whose demands are not exactly the same, if it is to find a market. Mr. Charles Wilbur Leigh, of the Armour Institute of Technology, experienced the difficulty referred to in dealing with his courses of work in evening classes. As no single available work met the needs of his students, he met the difficulty by writing a pamphlet on "*Practical Mechanics and Strength of Materials.*" This he has extended to meet a more general appeal, and it was published recently in book form at a price of 11*s.* 3*d.* net, under the original title by the McGraw-Hill Publishing Company, of Bouverie-street, London. In his treatment of the work, the author has dealt with some of the fundamental principles of mechanics at the beginning of each chapter and then demonstrated their application to the subjects of strength of materials and theory of structures. The standard of mathematical knowledge expected from the readers has been kept down to a working knowledge of algebra, geometry and trigonometry, and for men who have those requirements and who desire a working knowledge of the subjects dealt with the work will be found very useful.

The conservation of mineral resources is undoubtedly of foremost importance, and the fact that the melting of brass by electrical means effects material saving in the metals melted has led the United States Bureau of Mines to investigate the whole subject. The results of the research are published in an excellent report written by Messrs. H. W. Gillett and E. L. Mack, on "*Electric Brass Furnace Practice*," Bulletin 202, United States Department of the Interior, Bureau of Mines, Washington. (Price 50c.) Loss of zinc by volatilisation has always been a serious problem in fuel-fired crucible furnaces. This loss is mainly due to the fact that there is always a flow of products of combustion over the metal which continually carries off vapours of zinc oxide. In electric furnaces, however, there is no flow of products of combustion and the furnace can be kept tightly closed. The data given throughout the work shows that the adoption of the electric furnace has been followed by an appreciable decrease in metal losses. The saving in labour and the improved health of the workmen, due to the absence of noxious fumes, is another great step forward. All types and sizes of electric furnaces used and usable in non-ferrous melting are fully considered, and details, such as current consumption, yield and pouring temperatures, are set out in tabular form. The plates and diagrams are numerous, the former showing furnaces at work in various American foundries. Prior to 1916, the electric melting of brass was in the experimental stage, but by the end of 1921 some 413 furnaces of various types and sizes had been or were being installed in the United States. The initial cost of any electric furnace is relatively high, and it is usually more expensive to maintain than a fuel-fired furnace, but the authors contend that in the great majority of cases the electric melting of brass is both the best and the cheapest

method, and that electric furnaces, by their sheer superiority of service, must ultimately take a dominant place in the non-ferrous foundry.

The association between the engineer and the architect is growing closer, and with the increased use of reinforced concrete and other materials in building, the connection is likely to become more intimate. This seems to be the view of Messrs. W. R. Jaggard and F. E. Drury, the one, a Fellow of the Institute of British Architects, the other, of the Institute of Sanitary Engineers, who together are responsible for a work on "*Architectural Building Construction*," published by the Cambridge University Press. In this work apparently much information is conveyed that would be equally valuable to the architect and the engineer, but, unfortunately, we have not the earlier published portion that would assist the formation of independent opinion. Judging, however, from this sample (price 18*s.*), Vol. II., part II., the authors are striving to exhibit the relations between building construction and the principles of architectural design. They insist, very properly, on the performance of good, honest work, where meretricious ornament and excessive decoration does not hide slovenly craftsmanship, and undoubtedly their object will be promoted if the architect possesses adequate knowledge of the proper use of materials, and of the scientific and fit assembly of the varying units. Aesthetics, as generally understood, the production of what is simply pleasing to the eye, would seem to take a second place in this programme. Good workmanship, however, need not necessarily exclude artistic effects that appeal to cultured taste, and the authors recommend the study of the creations of other ages and other climes as furnishing appropriate models for the application of modern methods and requirements. In this section of the treatise, it is the work of the joiner and the plumber that comes mainly under review. The designs and construction of floors and roofs are described and illustrated, plans for doors and windows, stairs and fittings are recommended with an elaboration that all can enjoy, but which will probably find small place in the Government subsidised houses of which we have heard so much. The plumbers' fittings, inside and out, are conceived on what some might consider generous lines, but those who can afford the expense would do well to follow the general plan disclosed. The authors state that the question of cost has not been overlooked, and add what is perfectly true, though all of us may not be able to profit by the suggestion, that an apparently costly structure may be so economical in maintenance, that ultimately it will prove cheaper than a building whose low first-cost seemed to promise economy. The work is intended for class teaching as well as for professionals. The first volume was arranged to meet the requirements of first-year students, the present is more especially adapted to second-year and advanced students. The plan followed, one that ought to prove interesting, is to imagine and to follow the construction of two classes of building, the one, a semi-detached suburban house, the other a town warehouse. Such erections, it is contended, can be made to embody all the items necessary for an elementary knowledge of building construction, and to furnish a sufficient variety of application. The book is profusely illustrated with original diagrams, the authors preferring isometric or pictorial projection to the more ordinary orthogonal presentation of examples, claiming that the solidity of the object is better conveyed to an elementary student. We find the diagrams rather overloaded with description, but this fault, if it be one, would be overcome by adopting the authors' recommendation that the student should be encouraged to construct correct scale models.

ROAD MATERIAL PREPARING PLANT.

(*Concluded from page* 683.)

Turning next to tar macadam plant, demonstrations were given of several machines for stone drying and tar macadam mixing. Unfortunately it was not possible at Cardiff for all these to work under a very wide range of conditions, and some were consequently reserved for subsequent tests. One of the most complete reports was made in connection with a 7 cub. ft. sized plant by Messrs. Stothert and Pitt, Orchard-street, Westminster. The normal output of this machine is from 30 tons to 40 tons of tar macadam per 8-hour day. The design shown at work was of the portable type illustrated in the photograph reproduced in Fig. 10, on page 707. This plant had the exceptional distinction of being "highly commended," and is reported upon as well designed and of good construction, and well adapted to its work. As regards design, workmanship, stability and durability it is stated to be "very good in every respect."

This plant is of such a size that it can be taken out on the road to wherever work is being carried out. It is driven by belt from an independently mounted 8-b.h.p. to 9-b.h.p. Lister petrol engine, taking at the trials about 6½ pints of petrol per hour. The plant consists of one drum for drying the stone, and a second for mixing the stone and tar. The end-loading skip filled with stone is hoisted up guides and discharged into the drying drum. This rotary drier is connected with a furnace placed below the machine, in such a way that by means of a fan at the top of the machine the hot gases are sucked through it, being then exhausted into the air (as at Cardiff) or passed through a cyclone dust collector as fitted to the plant in Fig. 10. The furnace burns coke and uses from 1 cwt. to 1¼ cwt. of coke per hour for drying. After the stone has been in the drying drum long enough it is discharged by chute to a tilting drum Smith mixer, and the required amount of tar is sprayed into the mixer. The action of the spray, combined with the blades of the mixer, produce a thoroughly mixed batch, described by the judges as being of "a very satisfactory character." A batch passes through the machine normally in about 4 minutes, though this is dependent to some extent upon the weather, and the stone can be allowed to remain in the drier as long as necessary. The batch is discharged by tilting the mixing drum. The plant obviates all handling of the tar in buckets. A Feuerheerd pump is used for pumping the tar from the tar boiler alongside into a tar measuring tank placed above the drier and heated by the furnace gases. The operator has complete control of the tar supply and an indicator shows the exact amount of tar passing into the mixing drum. All the control levers are brought close together. This plant requires one man acting as driver, and two or three filling the loading skip.

In Figs. 11 and 12 we illustrate a similar plant by Messrs. Stothert and Pitt, of a larger size. The larger plants would ordinarily be fixtures as shown though a portable pattern is built. This plant is of 16 cub. ft.

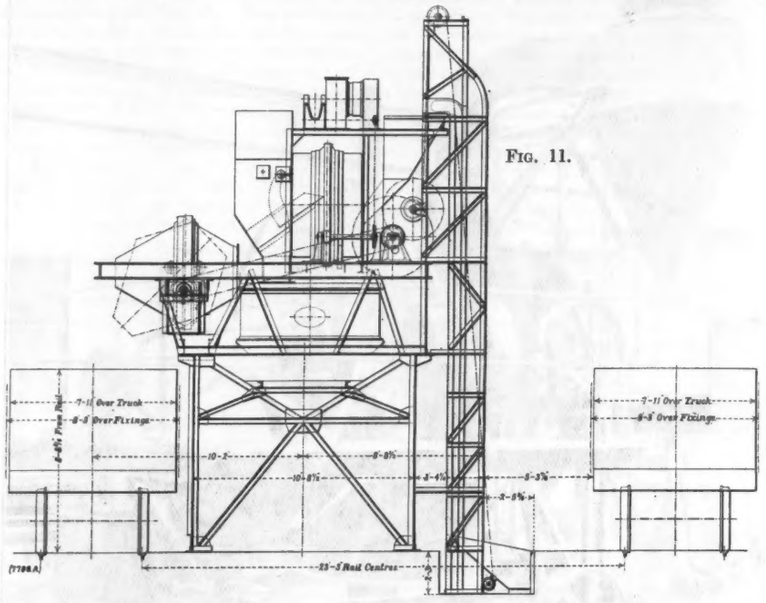


FIG. 11.

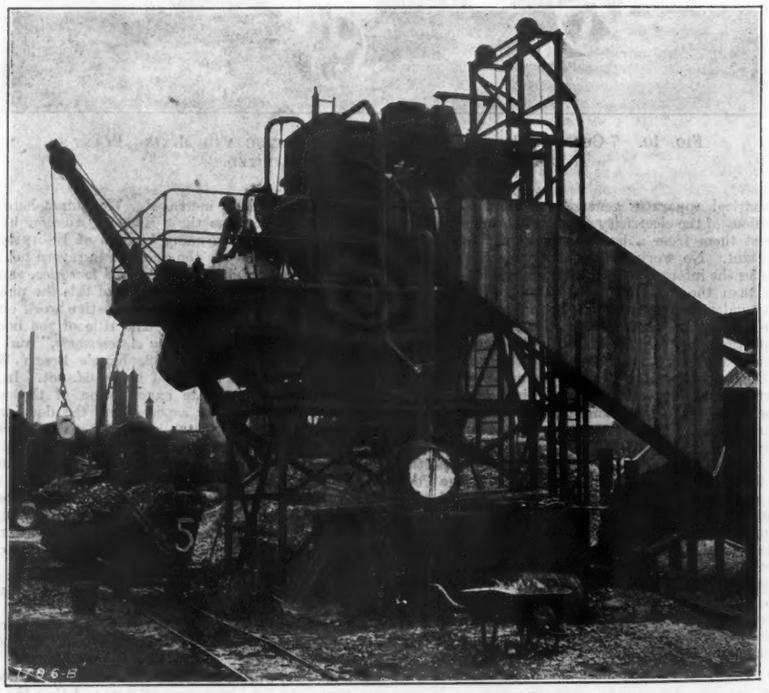


FIG. 12.

FIGS. 11 AND 12. FIXED TAR MACADAM DRYING AND MIXING PLANT; MESSRS. STOTHERT AND PITT, LIMITED.

capacity and has an output of from 60 tons to 80 tons per day, working at the rate of about 15 batches per hour. It is arranged so that it is possible to run carts or railway wagons directly under the discharge,

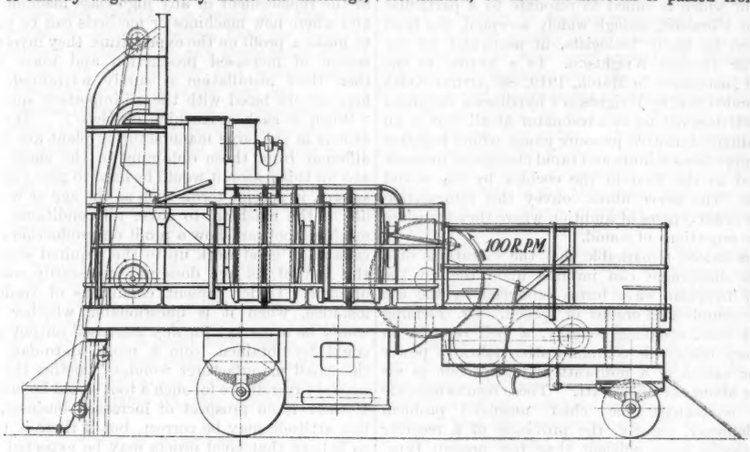


FIG. 13.

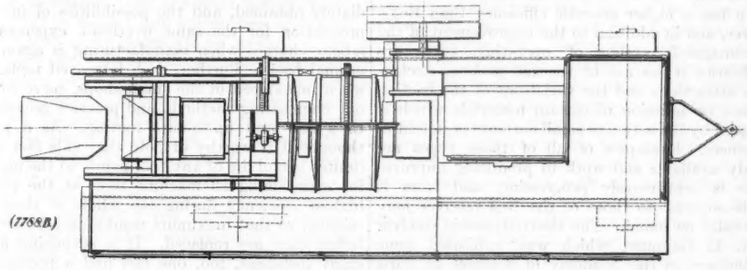


FIG. 14.

FIG. 15.

FIGS. 13 TO 15. PORTABLE TAR MACADAM DRYING AND MIXING PLANT; THE RANSOME MACHINERY COMPANY (1920), LIMITED.

while the loading skip is let down into a pocket in the ground so as to facilitate shovelling from dump heaps or wagon floors. These arrangements are easily modified to meet the conditions of particular cases.

In both these machines the drying drum is fitted with hopper blades, while the cone ends of the mixers are fitted with renewable liners. The mixer is fitted with spiral blades alternately right and left-handed, so that the material is passed from one end of the drum to the other and back again as it is turned over.

Another tar macadam plant reported as having good all-round efficiency, and being good as regards design, workmanship, strength, durability and accessibility, was the portable plant of the Ransome Machinery Company (1920), Limited, Grosvenor Gardens, London. It was not possible to complete the trials of this plant which was reserved for subsequent tests, but as it has been classed well, and is a plant which has proved its value in service, particulars of it may be included here. In the size illustrated in Figs. 13 to 15, annexed, and exhibited at Cardiff, the plant consisted of a double drum drier, and double drum mixer. The plant is portable and usually belt-driven from an outside source of power, and takes about 14 h.p. to run it. It is usually blocked up for working so that a cart can be run under the discharge. At one end of the plant is an elevator-loader, the skip having a capacity of 5¾ cub. ft. The skip is tipped into a one-batch hopper, from which a chute delivers the material into the first drying drum. From here it is passed on to the second drum, and after this is delivered to the mixer. This is a twin-barrelled machine in which revolve two shafts to which are fixed sets of paddles with renewable shoes. The discharge is through a trap in the mixer bottom.

The drying drums are cylindrical and arranged horizontally. Each runs on two tyres on rollers, and each is driven by a toothed ring and pinion. The drums are lagged with asbestos protected by cleading. Inside the drums are arranged curved wings by which the material is continually picked up to be dropped through the hot gases from the upper part of the drum; baffles are also provided for working the material on to the discharge chute when this is inserted into the drum. Hot gases from a coke furnace, suspended from the main framing, are drawn through the drying drums by a fan, the discharge from which is passed into a cyclone dust collector. The fan is belt-driven from a countershaft run off the shaft which drives the drums and the elevator hoisting gear. The coke furnace is completely lined with firebrick and has a brick arch. The double shaft mixer is driven by chain from the main pulley shaft. The two mixer spindles are fitted with gears in mesh and the chain drive is transmitted by gear to one of these, which in turn transmits to the other. The discharge from the mixer is very prompt, allowing no time for settlement. The plant is usually furnished with a tar tank kept filled by a pump from the supply as it comes to hand in barrels or otherwise. A measuring trough is arranged above the mixer, and this is filled from the tank and tipped into the mixer for each batch.

The elevator is furnished with an enclosed clutch running in oil, and has automatic throw-out and brake gear. The skip discharges in 3 seconds or 4 seconds, and then descends for the next batch. The hopper into which the elevator discharges enables the skip to be lowered out for re-loading even if the drums are not quite ready for fresh material. A point of interest is that the whole of the top gear of the elevator, the fan unit, &c., are on a detachable framing which can be removed so as to reduce the height of the equipment when transferring from one point to another site. The size of machine we have been dealing with has an approximate capacity of 4½ tons per hour of ½-in. tar macadam. The same machine will turn out about 5 tons of 1½-in. tar macadam or 6 tons of 2½-in. macadam. The coke consumed runs out at about 1 cwt. per hour, A staff of five is required, viz., one man for operating, two for loading and two for removing the discharged material. All the control levers are arranged to be worked from the operating platform on one side of the machine. When operated efficiently five batches are being handled at once; one is in the mixer, one in the second drying drum, one in the first drum, a fourth in the hopper, while the fifth is being loaded into the skip. Operation can, however, be varied to suit the aggregate which may be retained if necessary rather longer in the drying drums. In fan-operated machines of course the small dust is removed during drying out, and this does not pass on to the mixer.

SWEDISH ENGINEERING.—Swedish engineering has been severely affected by the general depression and by German competition. From the former there is a marked recovery and the latter is subsiding. The year 1921 was a difficult year, and whilst such an important concern as the Swedish Ball Bearings Company had a deficit of 12,729,000 kronor for 1921, it has just managed to avoid a deficit for 1922, there being a net profit of 27,000 kronor. Other concerns continue to show substantial losses for 1922, whilst the important Grangesberg Mining Company has earned net profits for last year of 14,452,603 kronor. A sum of 16,998,300 kronor was derived from the Luossavaara-Kirunavaara Company. The shareholders receive 10 kronor per share. The dividend is the same as for the previous year. Another large concern, the Uddeholm Company, last year but one had losses amounting to 12,660,000 kronor, whereas for 1922 they earned net profits amounting to 536,000 kronor. The ore mining industry is hampered by the French occupation of the Ruhr, as Westphalia is Sweden's most important buyer of iron ore, and shipments have been stopped for more than two months. The Luossavaara-Kirunavaara Mining Company is at present working only four days per week, and still further reductions of hours are reported to be probable.

RESEARCH AND TELEPHONY.

PROFESSOR J. A. Fleming, in his recent Kelvin lecture on "Problems in Telephony, Solved and Unsolved," to the Institution of Electrical Engineers, traced the lines of progress and the application of pioneer investigations to that art of communication, and then ended with a lament. After such a romantic story of progress, in which men of British birth played a large part, the necessity for concluding with a dirge must be apparent to all who know the actual dimensions of the real research work in telephony conducted at present in this country. We must agree with Dr. Fleming that there is a vast difference in the extent of the provision for true research in America and in our homeland, and there is an essential difference in the outlook regarding personnel.

Few of our laboratories are comparable with those of the United States. Professor Fleming cited the new laboratories of the General Electric Company at North Wembley, the National Physical Laboratories at Teddington and, to a smaller extent, the Post Office Research Laboratory at Dollis Hill as the only British institutions which could be compared in any way with those of the great technical corporations in the United States of America. He regretted the tendency in Britain of expecting an immediate commercial return from investigation work or, at any rate, the undertaking of only such work as has a close relationship with industrial application. The outlook of considering that research work can be fostered by small scale expenditure on scholarships or committees or usefully conducted by men of mediocre powers also merited Dr. Fleming's disapproval. The whole question of research work is one of personnel, and we welcome the implied criticism of the many institutions where the work has been put into the hands of men lacking in initiative and almost devoid of originality.

As telegraphy and telephony are in the control of the Government in this country there is very little inducement for private investigators of high ability to take them up as the subjects of their labour. It is to be deplored, however, that there is not a single University in this country possessing in its electrical engineering department the necessary equipment for conducting advanced experimental investigations in this field. We have never lacked men of the highest scientific originality, men such as D. E. Hughes, Oliver Heaviside, Lord Rayleigh and Lord Kelvin, but even the importance of their work was not always recognised immediately, or followed up with large scale investigations, with the result that much of its practical significance reached us from foreign countries. That there are men of similar capacity available to-day is possible, but there is not much indication of a desire to utilise their efforts. It is sad to think that in an Empire scattered over many seas, whose welfare is bound up with the continued extension of the means of communication, so little research work should be done in telegraphy and telephony.

In the early part of his discussion of the efficiencies of performance of the separate components in telephony, Professor Fleming referred to the human organs of speech and hearing as well as the instruments and line. If speaking was assumed to be carried on for an hour, it has been determined that the energy represented during ordinary speech by the air waves was only $\frac{1}{2}\frac{1}{0}$ of a foot-pound. When speech was loud, as in the case of lecturing, the amplitude of the waves was increased and the air wave energy made greater; the waves representing an expenditure of between 20 ft.-lbs. and 25 ft.-lbs. in an hour. Such results, contrasted with the fatigue effects produced in speaking to large audiences, gave an indication of the smallness of the efficiency, in the technical sense, of the human vocal organs when considered simply as energy translating devices for the production of speech-wave energy.

Any improvement in telephony must be largely dependent on the knowledge of the nature of speech sounds and of the operation of the ear in appreciating them. The ear is one of the greatest marvels of creation. Professor Fleming spoke of it performing a sort of instantaneous Fourier analysis of complex air-wave forms, appreciating the harmonics present with the fundamental tone, and not only their relative amplitude but to some extent their phase difference. The theory of von Helmholtz, later modified by Gray, that the Corti organ may be regarded as a microscopic harp of 10,000 strings, each of which is tuned to resonate to a particular rate of vibration, though widely accepted, has been rejected by many biologists, in particular by the late Sir Thomas Wrightson. In a lecture to the Royal Institution in March, 1919, Sir Arthur Keith expounded that by Wrightson's hypothesis the organ of Corti does not act as a resonator at all, but is an exceedingly sensitive pressure gauge which registers and appreciates minute and rapid changes of pressure applied to the fluid in the cochlea by the sound waves. The nerve fibres convey this information to the brain centres of audition where they translate it into sensations of sound.

It is indeed remarkable that the vibrations of a simple diaphragm can impress upon the air the highly irregular wave forms produced by the use of the complicated organs of speech. Dr. Fleming stated that, speaking roughly, a Bell receiver in ordinary telephonic communication takes in power to the extent of a milliwatt and gives out as air waves about one microwatt. These results indicate what is perhaps the chief unsolved problem in telephony, namely, the provision of a receiver acoustically more efficient than the present type, and with equal or better speech reproducing power. Undoubtedly the steel reed instrument of S. G. Brown has a higher acoustic efficiency than Bell's receiver, and in addition to the improvement of the electromagnetic system of operating, there are possibilities in the use of thermal actions, electrostatic attractions and the variations of the friction between or adhesion of certain materials which is produced by the action of small currents or potential differences. Examples of all of these types are already available and work in producing improvements is continuously progressing, and from it results superior to those of the Bell receiver may eventually be found. The electrodynamic receiver of M. L. Gaumont which was exhibited some months ago to the Academy of Sciences at Paris seems to possess great possibilities, but few have been so far available for test, at any rate in this country. The results of the preliminary tests referred to at the Paris meeting suggest that there is hope of a decided improvement in efficiency of a commercial instrument immediately.

There are many interesting problems in connection with the telephone line of which fairly satisfactory solutions have been found in the last few years. The reduction in the weights of telephone lines made possible by the introduction of loading has extended the field of economic service of the telephone very greatly and a further great extension was secured by the invention of the thermionic telephone repeater. Professor Fleming invented the oscillation valve or thermionic rectifier, and to that and to Lee de Forrest's introduction of the grid to control the electron current by electrostatic action we owe the production of the modern valve, an instrument of remarkable utility in telephone repeating and in wireless telephony. Mr. Frank Gill showed in his presidential address to the Institution of Electrical Engineers in October last how the introduction of the thermionic repeater had rendered commercially possible a vast extension of telephonic range. Another useful field of service for the thermionic valve was found in carrier wave multiple telephony.

THE PURCHASE OF MACHINE TOOLS.

MACHINE tools purchased solely as a result of, and for, plant extensions obviously absorb only a relatively small proportion of the total output each year. The remainder are utilised either for new processes or to replace obsolete plant. Not often, though, does this question of replacement receive, on proper methodical lines, the consideration it deserves. At the same time the enhanced activity of the machine tool salesman has served to direct attention increasingly to this point, and it can safely be assumed that otherwise, in quite a good number of instances, a machine would have to become totally unfit for work on modern lines before being discarded. The salesman, however, is now abroad armed with new production schemes, and offers his tools in the light of the increased output and lower costs which can be attained by their use.

Obsolescence should be the determining factor in the replacement of any high-class machine tool, and where new machines or methods can be proved to make a profit on the expenditure they involve by reason of increased production and lower costs, then their installation is surely warranted. But here we are faced with the all-important question, "When is such a machine obsolete?" The conditions in the large manufacturing plant are totally different from those obtaining in the small shop, and for this reason it would be hard to give a definite answer, in specific terms such as the age or working life of the machine, to cover all conditions. If a machine tool can show a profit on production and is capable of good work up to the required standard, the fact of its age does not necessarily make it obsolete. Under present conditions of trade, for instance, when it is questionable whether there would be a market for any increased output which could be obtained from a more up-to-date tool, the small manufacturer wonders whether the large capital expenditure for such a tool would be justified. If there is no prospect of increased business, then this attitude may be correct, but if there is reason to believe that good orders may be expected when trade revives, the purchase of a new machine is fully warranted by reason of the reduced costs immediately obtained, and the possibilities of increased production for the same overhead expenses and labour charges when manufacturing is again on a normal basis. Further, such improved tools, even when introduced in the small shops, serve to place our engineering methods and practice generally on to a new and up-to-date footing. As a passing thought it is worthy of note that this fact of the limited useful life of any tool points to the necessity for maintaining all machine tools at the point of highest efficiency during the whole of their commission, so that maximum results may be obtained before they are replaced. It is surprising in how many instances, too, one can find a peculiar persistence in retaining obsolete plant from sentimental or "ancient-history" reasons.

From these considerations it is deduced that the new machine must save money, for surely this is what we have in mind when we speak of reduced costs and increased output. It is on the possibilities in this direction upon which the machine tool manufacturer depends for a steady trade, and his ingenuity is utilised in developing new designs which will justify the relegation of older machines to the scrap heap, or at least for sale elsewhere, even though these latter machines may be good for production for some time yet.

Careful deliberation is necessary in weighing up all these points to determine exactly whether the investment in a new machine is justified, but not yet have these considerations been developed to such a fine degree in the majority of even the largest of our engineering establishments. Too often does the initial capital outlay immediately loom up as a "bogey" when new machines are spoken of, and this fact is allowed to rule out of consideration the advantages to be derived from such machines. It is pleasing to note, however, that this shortsighted policy is gradually but surely giving way to a wider vision. The purchase of a machine tool is an investment and the return on such investment determines its value. The present state of trade has served acutely to remind manufacturers of the fact that haphazard methods or lack of definite methods cannot be tolerated, and every endeavour is necessary to place production on as near a 100 per cent. efficiency basis as is practicable. Thus will be appreciated the need for first-hand information as to the relative value, from a production standpoint, of every machine of a plant. In such a case the cost of an old machine, both in repairs themselves, loss of production during these idle periods, and the delay in the proper manufacturing progress, is readily observed. Immediately these losses become anything like appreciable, it is obvious that the point of economy in retaining such tools has been passed, and the question of the profit to be earned by the installation of new machines should come up for consideration. Whilst on this point it should be mentioned that in a similar manner true economy does not mean the purchase of the cheapest machines,

but the relative saving in relation to the cost price should be the determining factor. Very often comparatively cheap machines will meet certain requirements, but usually it is found, and this has been proved in actual practice, that for definite manufacturing conditions on any appreciable scale, machine tools of high quality and workmanship provide the truest economy in the long run.

If conditions have decided that the purchase of a new machine is warranted, careful consideration as to exactly which machine is best suited for the purpose then becomes necessary. It does not always follow that the replaced machine should be of the same type as the one already in use, since new tools and methods may have been devised for the work in question. True jigs, fixtures and special cutting tools may be already in use, and if a totally different machine is brought in may not be suitable, but in considering such a totally different machine the loss in this respect should be taken into full consideration in judging the profit to be made on the investment. Machine-tool makers are usually able to guarantee a production on their machines, and this enables an estimate in this direction to be readily made.

The class of labour to be provided for the new machine should also be borne in mind, for if careful setting, accurate reading, or any complex manipulation are necessary, then the most highly-skilled operators will be needed, and unless these are found it is likely that many pieces will be spoiled, at the outset at any rate. To obviate this, many engineers have favoured single-purpose machines, but in these cases it is necessary to have a continuous production of standard components to keep such single-purpose machines successfully employed. Recognising the value of some attention to this point, machine-tool makers have endeavoured to keep their designs as simple as possible and to strike a happy medium by producing standard types suitable for one or more operations rather than endeavouring to provide machines suitable for a number of uses. The result has been to enable purchasers to find in the range of standard tools those suitable for their own needs without being involved in the purchase of special machines. Varied opinions are held as to the relative advantages and disadvantages of these latter. Certain it is that the special machine does hold out advantages of its own, but in view of the fact that plant becomes obsolete when new designs afford increased profit on production, coupled with the wide range of standard machines available for varying requirements, this resolves itself into a question of whether the increased price for a special machine is thoroughly justified. These latter are necessarily higher in price, since pattern costs have to be borne by the purchaser, and the advantages of repetition machining are not obtained in their production, the cost of repair parts also being in excess of those for a standard machine. The delivery of the special machine is also necessarily more extended than for a standard type, especially when the machine-tool builder is fully engaged on the production of these latter. Whilst it is not intended to fully discuss the relative advantages of these tools, it should be noted here that the profit on production from a special machine provided that a regular run of work for which the machine is designed is likely to be forthcoming, may fully justify the installation of such a tool. The principles outlined above should be the sole determining factors in the choice in this connection, assuming, of course, that the whole plant is working on a normal basis and the future can be looked forward to without any excessive fear of abnormal conditions. By normal conditions is implied the steady development which all businesses have a reason to expect when run on the right lines and with proper endeavour.

The full value of many a modern machine tool is not always utilised through lack of proper attention to the matter of tooling and accessories. The efficiency of a machine varies to a very big extent in proportion to the suitability of its equipment. The machine-tool maker has given the necessary attention to operative convenience, minimising of adjustments, etc., in order to make for high production, but is in the hands of the user in so far as the machine equipment is such as to enable fullest advantage to be taken of these productive features. Exactly as in the case of the machine so with the equipment; the initial cost must be considered in relation to the results to be obtained. Careful attention to tooling equipment will make an old machine equally as profitable as one of the latest design but with poor equipment. Thus the value of the machine and the tooling are interdependent, and the obtaining of maximum machining with the minimum of idle time depends equally on one as on the other. Doubtless these facts will be appreciated without quoting specific instances, but whilst apparently pointing to the obvious, it is safe to say that many instances could easily be found where practical appreciation of this vital fact has been missed.

During the last few years there has been an increased appreciation of the assistance which machine tool makers are willing to render to their customers, and this assistance is in the interests of both parties. The user pays for a machine of high quality, and has every reason to expect that same shall be designed and built "right." On the other hand, the machine-tool maker knows the possibilities of his machine and has every right to expect that the necessary care will be taken in the use and handling of same; for instance, in regard to correct and adequate foundation, drive, lubrication and the general care that bearing surfaces and all vital parts shall be kept free from dirt, cuttings, etc., where it is not practicable for these parts to be enclosed. Before purchase the maker is willing to co-operate with the client and to place at the latter's disposal the result of a practical experience, gained through painstaking effort and endeavour, and to assist in the correct choice of machine and equipment for the operations to be performed. Further, the maker's interest in the machine does not end with its installation, but continues during the whole of the time it is in commission, and many firms have adopted a praiseworthy policy of initiating a service which includes periodical visits by an expert to clients' works, to check that machines are running correctly, that best advantage is being taken of their possibilities, and to give such advice in connection therewith as may be desired. One is led to think that if all the facts set forth were given the consideration which they deserve, many "ancient warriors" would be speedily replaced by new and more up-to-date machine tools, capable of giving better and more economical production and of placing engineering methods generally on a truly modern basis.

MINING EXHIBITION AT THE AGRICULTURAL HALL.

THE mining industry, which in this country means pre-eminently the coal-mining industry, is most frequently brought under the notice of the population of London by reports of labour difficulties in the coalfields or by announcements of a change in the price of domestic coal. The methods by which some 250,000,000 tons of coal per annum are extracted from the depths of the earth in Great Britain alone, and the innumerable auxiliary processes and types of equipment which serve the mining industry, are hardly thought about or understood. It is impossible, in the nature of things, to reproduce the atmosphere of underground workings or pit-head conditions in an Exhibition Hall, but those who are interested in mining and kindred subjects will find much for their attention in the International Mining Exhibition which was opened on the 1st inst. by Sir Philip Lloyd-Graeme, the President of the Board of Trade, in the Royal Agricultural Hall at Islington. This exhibition is the sixth of its kind, the last being held in 1913. Its title of "International" is justified not only by the representation of the French, Belgian, Mexican and Colombian Governments, but by the number of private firms of foreign nationality who are participating. There is indeed a complete French section, and Belgian firms are also well represented, in addition of course, to prominent American manufacturers of mining apparatus. The scientific and safety aspects of the industry are represented by exhibits of the Safety in Mines Research Board of the Mines Department, the Explosives in Mines Committee, the Mines Department Testing Station, the Lancashire and Cheshire Coal Owners' Research Association, the United States Bureau of Mines and various universities and other bodies, while the Imperial Institute, the Geological Survey, the Imperial College of Science and Technology, the Imperial Mineral Resources Bureau and the Gold Coast Geological Survey all contribute samples, models, maps or other matters of mining interest. Exhibits of this nature are collected together in the Gilbey Hall, the floor of the main building being devoted to stands displaying the exhibits of manufacturing firms concerned directly or indirectly with the mining industry.

Among the exhibitors of mine-haulage gears are Messrs. M. B. Wild and Co., Limited, of Nechells, Birmingham, who show the machine illustrated in Fig. 1, on page 712. This is an electrically-driven haulage, one of the principal features of which is the "Spence-Wild" reduction gear employed between the motor and the winding drum. The mechanism of the gear is shown diagrammatically in Fig. 2. The arrangement consists of worm drives with a further reduction by spur gearing. The first reduction is effected by a perfectly balanced, and therefore thrustless, double worm gear, consisting of a worm shaft A having right and left-handed worms gearing into their respective worm wheels B. The second reduction is of the spur type consisting of two pinions C gearing into a common spur wheel D, keyed to the final shaft. By fitting another similar worm shaft A1 with worm wheels and spur pinions B_1 and C_1 respectively, the reduction ratio can be approximately doubled without increasing the size of the box. A cross coupling E is fitted between the worm shafts in this case to allow an endwise movement sufficient to distribute the load equally. The final shaft F is carried in roller bearings, and the fact that the gear casing forms an oil bath effects a very great reduction in the friction as compared with ordinary gears. The gear, moreover, is very compact and runs with extreme quietness. Gear, of the type in question, is standardised in six sizes from 10 h.p. to 100 h.p., and is also built for transmission of powers up to 300 h.p. The machine shown at the Exhibition has a 20-b.h.p. motor and a haulage speed of 4 m.p.h. With more powerful haulages the speed is increased, a 100-h.p. plant having a rope speed of 10 m.p.h. For the control of the winding drum a band clutch is fitted, which is arranged to work equally well in either direction of rotation. This type of clutch enables the load to be taken up so easily that an ordinary squirrel-cage motor can be used with the gear, which is both cheaper and safer in a mine than any other kind. The band-brake fitted to the drum will work, like the clutch, equally well on either direction, so that the cable may be taken off the top or bottom of the drum as most convenient in any particular case.

Messrs. Ronald Trist and Co., Limited, of 12, Clipstone-street, Great Portland-street, London, W., are showing a device called the "Raybeam" electric gauge glass illuminator, for making it more easy to read the water-level in boiler gauge glasses. With the great height of modern power station boilers, observation of the water level from the floor is not as easy as it should be, and in spite of the numerous special gauge glasses invented to show the water level clearly, one often finds a sheet of paper behind the glass employed in preference. The Raybeam apparatus, illustrated in Figs. 3 to 5, on page 712, contains a small electric lamp entirely shielded from the eyes by a brass container. The light escapes from the container through a window of red glass, the red beam traversing the bottom of the gauge glass and meeting a curved reflector on the other side. This reflects it back into the interior of the glass in an upward direction, and where the light meets the meniscus of the water in the glass the water level is shown by a bright, luminous band. The effect is very striking and gives a perfectly clear indication of the water level at any distance from which the glass itself is visible. Several of these illuminators are shown fitted to gauge glasses in the Exhibition, but, except on the stand of Messrs. Davey Paxman and Co., they were all working with cold water. On the latter stand, however, the boiler was under steam, and the effect did not seem so good, either because the apparatus was out of adjustment or possibly because the physical conditions of a meniscus of hot water in contact with its own vapour are different from those of

cold water in contact with air. The fireman in charge of the working boiler seemed, however, entirely pleased with the illuminator. These devices can be attached to any ordinary gauge glasses, and work off the electric light circuit. They need not, of course, be switched on except when an observation is desired, so that their current consumption is negligible.

The curious looking apparatus shown in Figs. 6 to 9, on page 713, is the "Rearer" safety carriage designed by The Worsley Mesnes Ironworks, Limited, Wigan, to prevent the serious accidents which sometimes occur on inclines in mines due to a train of tubs running away. This may occur either on account of the breakage of the haulage tackle, the failure of the brakes or loss of control by the engine man. The Rearer, as will be seen by the illustrations, consists of a carriage running on the same rails as the tubs, and carrying a pair of heavy steel scissors, or forks. The lower fork is held in position clear of the ground by a latch, which can be tripped by a spring-loaded governor on the axle of the vehicle. The governor flies out and releases the catch if the speed of the vehicle exceeds a predetermined speed, say 6 m.p.h., and the fork obtains a grip on the floor of the mine. On moderate gradients this is sufficient to stop and hold any ordinary train of tubs, but on steeper gradients the forks are so arranged that after the lower one has caught the floor the upper one shall rise and catch the roof, thus making it impossible for the tubs to run away. A safety carriage, such as that illustrated, has been at work in a North Staffordshire colliery for several months on an undulating incline 500 yards long, with a gradient varying from 38 deg. to 50 deg., and the roof varying in height from 4 ft. 6 in. to 7 ft. 6 in. above the rails. In actual practice it is found that the upper fork stops the train without tearing down the roof timbering, the check given by the bottom fork sufficiently arresting the speed of the train before the top fork comes into action.

The Sullivan Machinery Company, of Salisbury House, London, E.C. 2, show various types of mining machinery and appliances. One is a machine for sharpening the picks used in connection with coal-cutting machines. These picks are made of a rectangular section of steel bar, and resemble to a certain extent a round-nosed lathe tool with very pronounced top rake and front clearance. The old pick to be re-sharpened, or a piece of steel for making a new one, is heated at the end and dropped hot-end uppermost into a slot in the machine table. A reciprocating crosshead, running between strong guides and driven by the main crankshaft of the machine, carries at its outer end a grooved steel roller which passes over the heated end of the tool and reduces it to proper shape. The tool is supported against a backing-piece while this is going on, and can be raised or lowered by the operator. A general view of the machine is shown in Fig. 10, on page 713, and an enlarged view of the roller and adjacent parts in Fig. 11. The machine will make five or six new picks per minute and sharpen double this number of old ones. The picks leave the machine absolutely uniform in size and shape, and are provided with back-clearance which is rarely put on hand-sharpened picks. The machine takes 5 b.h.p. to drive it, and runs at about 75 r.p.m. It is shown on the stand making and sharpening lead picks, to demonstrate its action when dealing with heated steel. Illustrated in Figs. 12 to 15 on pages 716, are several of the same company's exhibits. Fig. 12 is a portable totally-enclosed mine-car air compressor designed for use in fiery mines. The machine is gas-proof, and is driven by a standard Sullivan electric motor as used for coal-cutters fitted with a drum type controller. The air compressor has a cylinder 9 in. diameter by 8-in. stroke, giving a displacement volume of 152 cub. ft. per minute when running at 260 revolutions. The normal delivery pressure is 100 lb. per square inch. The hardiness and compactness of the design is well shown in the illustration. The same company show applications of their "Turbinair" motor to hauling and hoisting purposes. This motor consists essentially of a pair of equal-sized double helical gear wheels running together in a closely-fitting casing. Air is admitted under pressure through a hole in the casing where it approaches the line of contact of the teeth, and between the opposed helices of the gears. The air is trapped between the teeth and the casing, and as it expands it causes the gears to rotate, escaping eventually at the ends of the teeth. A motor of this kind is placed inside the hoisting drum, which it drives by means of epicyclic gear. In the double-drum hoist, shown in Fig. 13, the two hoisting drums this way is shown in Fig. 14. The hoist, which weighs 555 lb. without the rope, is 20 in. long by 15 in. wide by 18·5 in. high. Each drum holds 225 ft. of $\frac{1}{16}$ wire rope, and either drum will lift 2,000 lb. deadweight vertically at 110 ft. per minute when supplied with air at 75 lb. per square inch. The motor is rated at 6·5 h.p., and sufficient air can be supplied to it through a $\frac{3}{4}$-in. hose line. If the air pressure is low the machine will still do

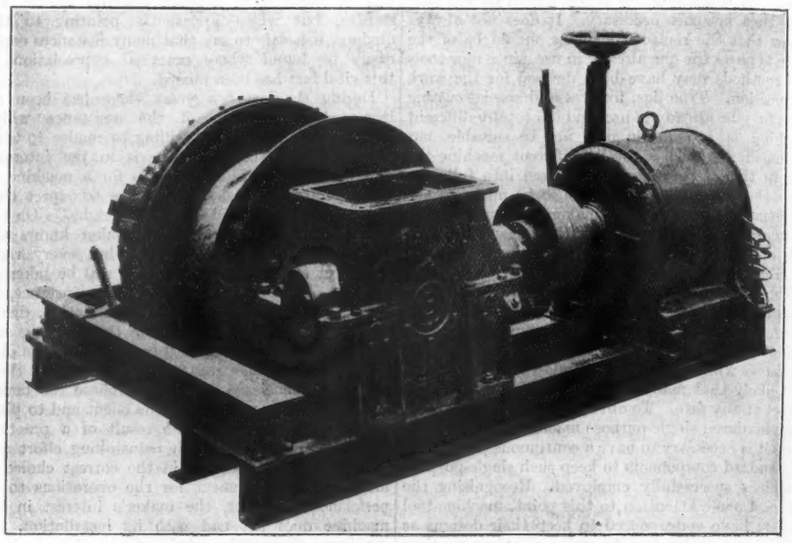
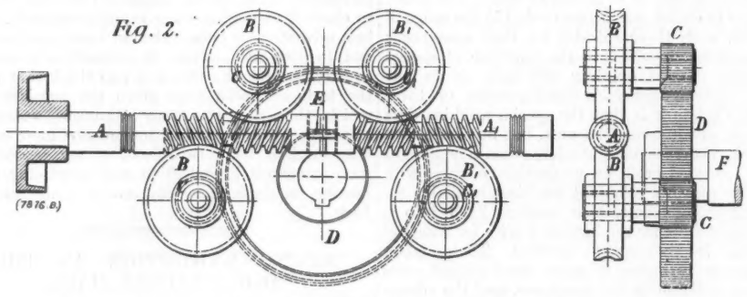
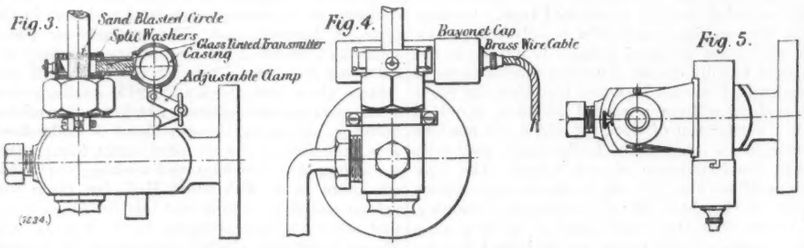


FIG. 1.



FIGS. 1 AND 2. MINE HAULAGE, WITH "SPENCE-WILD" REDUCTION GEAR; MESSRS. M. B. WILD AND CO., LIMITED, NECHELLS, BIRMINGHAM.



FIGS. 3 TO 5. THE "RAYBEAM" ELECTRIC GAUGE-GLASS ILLUMINATOR; MESSRS. RONALD TRIST AND CO., LIMITED, LONDON.

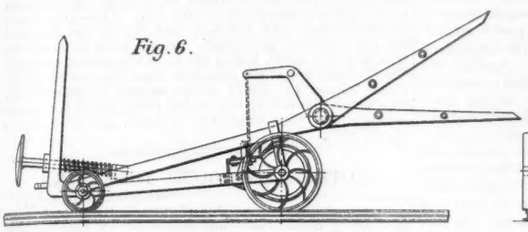
are each 10·75 in. diameter by 5·1 in. face, and each is controlled independently by a friction clutch and band brake. The clutches are at the outer ends of the drums and the brakes at the inner ends. Either drum may be operated separately or both used together. In "Slusher" work the live, or hauling, rope is attached to one drum and the tail, or return, rope to the other drum. The tail rope is paid off the second drum as the live rope is wound on to the first, and after dumping, the clutches are reversed and the car hauled back to its starting point. The operation of a double-drum hoist in its work, but at a lower speed, the rate of lift of full load with 50 lb. air pressure being reduced to 35 ft. per minute. There are obviously many useful applications for a hoist of this kind outside mining work. It is stated that its air consumption is less than that of corresponding air motors of the piston type.

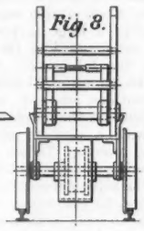
The "Turbinair" hoist is also built of the single-drum type. As before, the motor is inside, driving by epicyclic gear, and the hoist is controlled by a clutch and band brake at opposite ends of the drum. Such a hoist, capable of lifting 2,000 lb. deadweight

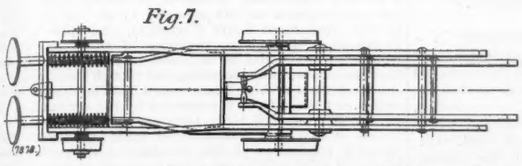
at 110 ft. per minute with air at 75 lb. per square inch, weighs 285 lb. without the 500 ft. of $\frac{1}{2}$ wire rope which the drum will carry. A single-drum hoist in operation in a mine is shown in Fig. 15.

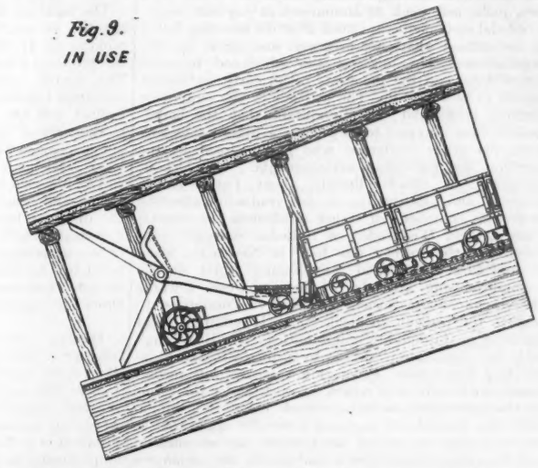
The engine has cylinders 9 in. and 15 in. diameter, with a stroke of 16 in. and running at 135 r.p.m. and taking steam at 140 lb. per square inch. it will develop the power mentioned. The engine is built

60 deg. F., also an "Essex" vertical boiler with 116·7 sq. ft. of heating surface, and an evaporation of 600 lb. of water per hour, and a vertical steam engine of 25 b.h.p. The workmanship of all









FIGS. 6 TO 9. "REARER" SAFETY CARRIAGE; MESSRS. WORSLEY MESNES IRON WORKS, LIMITED, WIGAN.

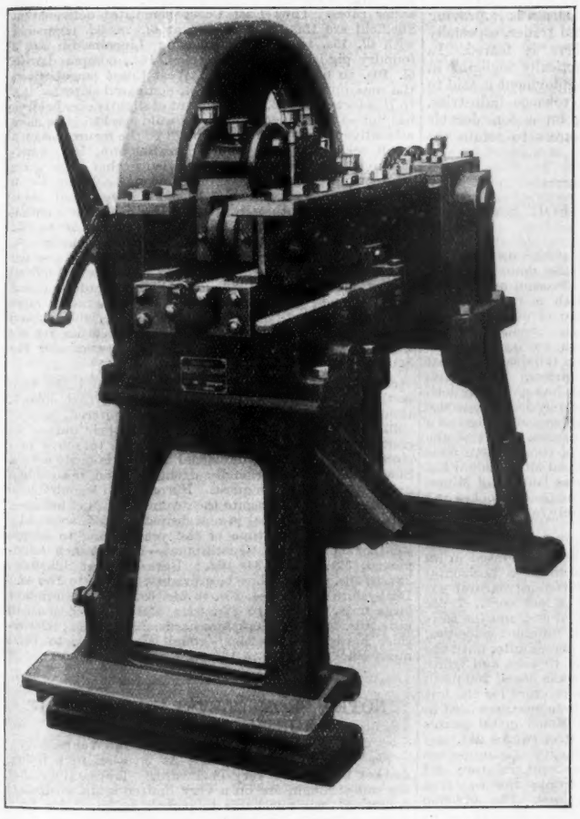


FIG. 10.

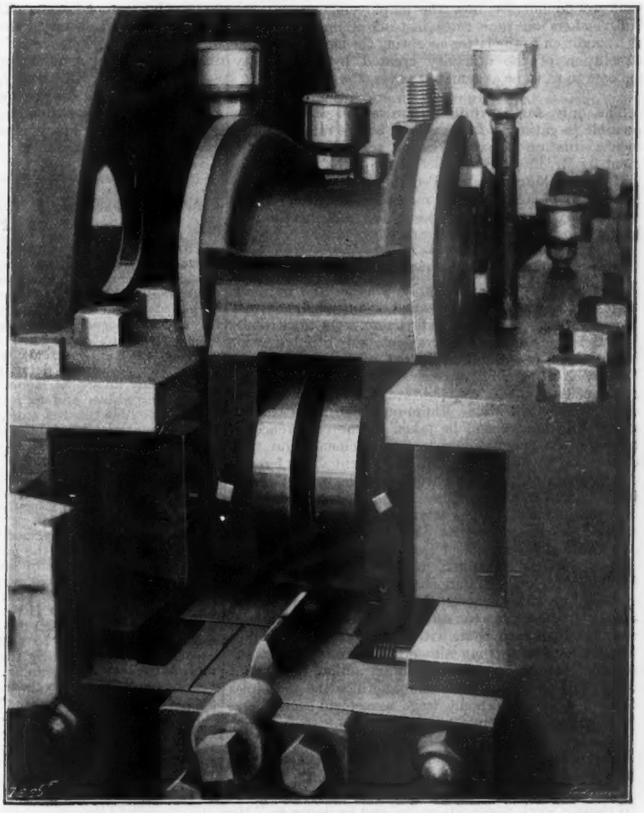


FIG. 11.

FIGS. 10 AND 11. MACHINE FOR SHARPENING COAL-CUTTER PICKS; THE SULLIVAN MACHINERY COMPANY, LONDON.

mounted on a post. It may, of course, equally well be bolted to a floor or wall or to any fixed object. The absence of reciprocating parts and the perfect balance of the toothed rotors ensure a noiselessness and freedom from vibration which are incidental advantages of the type of motor described.

Messrs. Davey Paxman and Co., Limited, of Colchester, Essex, have an unusually large display of steam engines and boilers, including a 50-b.h.p. compound horizontal engine running under steam supplied from a boiler of the "Economic" type. on a frame of steel channels, and the high-pressure cylinder is fitted with automatic expansion gear controlled by the governor. The boiler is 11 ft. long by 6 ft. 3 in. diameter, provided with a single 38-in. flue and 46 return tubes, 3 in. diameter. The total heating surface is 478 sq. ft. and the grate area 17·4 sq. ft. The boiler will make 2,400 lb. of steam per hour at 140 lb. pressure when supplied with feed water at 60 deg. F., and good coal as fuel. Other exhibits include a locomotive type stationary boiler, with 725 sq. ft. heating surface, capable of an evaporation of 3,200 lb. of water per hour from material on the stand is excellent and the display altogether is a striking one.

(To be continued.)

THE DANISH STATE RAILWAYS.—The Danish State Railways have published a provisional report for the financial year ending March 31, 1923. The year shows a surplus of 6,800,000 kronen, against a deficit of close upon 60,000,000 kronen for the preceding year. The receipts for the last financial year showed a decrease of 25,100,000 kronen (about 17,000,000 kronen on the goods traffic, &c., and about 8,000,000 kronen on the passenger traffic).

INDUSTRIAL NOTES.

THE meeting between representatives of the United Society of Boilermakers and Iron and Steel Shipbuilders and of the Shipbuilding Employers' Federation took place last week as announced in our last issue: no official statement was issued after the meeting, but it is understood that no progress was made in the negotiations. The meeting was adjourned to some future date, and the prospects of an early settlement appear to be doubtful. The attitude of the employers remains unchanged; they maintain that the boilermakers cannot expect to be put on a different footing from the other craftsmen who have agreed to the overtime and night-shift arrangements. The lockout continues; it effects directly about 10,000 boilermakers, and, indirectly, it is gradually affecting increasing numbers of other craftsmen in various centres. On Wednesday a national delegate conference of the society was held in Newcastle, when a resolution was passed "expressing regret at the uncompromising attitude of the employers towards the efforts of the Society's Executive Committee to remove the present deadlock which is entailing great hardship in shipbuilding communities. We therefore," adds the resolution, "decide to intimate to the Shipbuilding Employers' Federation that we will recommend our members to return to work under the terms of the agreement on a time-work basis, in common with the methods of payment generally applicable to other trades, or, as an alternative, we recommend our Executive Committee to submit to the employers and to the Ministry of Labour that we are agreeable to accept arbitration under the Industrial Courts Act on the existing dispute." We are bound to confess that we do not see how the employers can put the boilermakers on time rates instead of on piece rates as a condition to the latter accepting the agreement, and a solution of the difficulty created by the society appears to us to be as remote as ever.

The only further information which it has been possible to gather so far in regard to the railway shopmen's situation is that the ballot, according to a statement by Mr. Frank Smith, secretary of the Engineering and Shipbuilding Trades' Federation, showed a total number of 17,602 votes, the majority against accepting the railway companies' proposals for reducing the war bonus being six to one.

The special conference of the miners held last week in Blackpool considered simply whether the national wages agreement should be ended or amended. Formal discussion took place on the first day. On the second, Mr. Herbert Smith, the president, submitted a resolution moved on behalf of the executive by Mr. Frank Varley, Nottingham, stating "that in view of the arrangements made to facilitate the second reading stage of the Coal Mines Minimum Wage Act (Amendment) Bill, no decision be taken at the conference as to action on the national wage agreement, and that discussion be adjourned until the annual conference commencing July 10." There voted in favour of the resolution 622,000, against 122,000, a majority of 500,000 in favour. The adverse votes are stated to have been given by the Durham miners (120,000) and those of the Forest of Dean (2,000), the Cleveland miners having remained neutral. After the conference, Mr. Varley stated that this result was highly satisfactory, since it marked the recognition of Parliamentary activity as an established part of industrial action. He added that, without wishing to prejudice the position, he was not altogether optimistic as to the result of the proposed Parliamentary action, but even if it failed, the miners would not sacrifice the principles contained in the present wage agreement unless and until better alternatives were offered.

A general strike of the Belgian railway workers which had lasted about a month came to an end on the 1st inst. The syndicate, or union, has ordered all the operatives to resume work unconditionally, and in doing so "the syndicate is most gracious," says *L'Echo de la Rourse*, which appears to find that this order coincides with a number of eventualities. Among these the following are cited: The institution of an inquiry into the action of the "leaders"; the decision taken by the authorities to replace the drivers on strike by capable stokers; the insistence with which a large number of the men asked for a secret vote on the points at issue (a very grave feature in the judgment of the syndicate, for although an operative may be allowed to ignore the instructions of his chiefs in the business, it becomes the abomination of desolation if he dares to ignore the dictates of the "leaders"); and, in the fourth place, the Belgian journal adds, there is the fact that outsiders mobilised for running the services were getting quite proficient in the work. The strike has had for effect to increase the cost of living in Belgium, and will lead to still further additions to the index number. And yet the "leaders" state that in issuing their order to resume work their object was to prevent the strike from having anti-national results. Any strike, from its very commencement is anti-national in its effects.

The building trades ballot on the question of extending the 44-hour working week during eight summer months to 47 hours shows a large majority against the proposal which was put forward by the employers. The figures quoted are the following: Against the extension 118,000; for the extension, 11,600; majority against 106,400. Negotiations are now taking place in the various regions between the employers and the men's representatives with a view to arriving at a local settlement of the point. These negotiations will be followed by a meeting in London of the National Wages and Conditions Council to receive reports from the different localities and to endeavour to arrive at a decision where there is no local settlement. In case of no agreement being reached by the council, the point will be referred to arbitration. It is satisfactory to note that there is to be no cessation of work even should no agreement be reached by negotiation.

Dealing with the subject of unemployment in a number of different countries, the *International Labour Review*, the monthly journal issued by the International Labour Office of the League of Nations, reports that the greatest improvement is seen in the United States, where an industrial boom is in progress, and where production is higher than at the peak of 1920. Unemployment is practically non-existent; the mining, iron and steel, and building trades are employing every worker they can find. It is even anticipated that the limit of industrial expansion will soon be reached owing to the shortage of labour. The situation is improving in Canada, but in some of the skilled trades, especially engineering, a shortage of workers is feared. In France, unemployment remains practically negligible in extent. As regards Germany, unemployment is said to be most acute in the textile and tobacco industries, but elsewhere short-time working on a considerable scale has enabled many manufacturers to retain the greater part of their staffs.

MONEL METAL GAUZES FOR SAFETY LAMPS.

THE main requirements in the material used for the gauzes of miners' safety lamps of the flame type are mechanical strength, resistance to corrosion and a high thermal conductivity, combined with a melting-point higher than the ignition temperature of mine gas. Of the materials generally employed, viz., steel, brass and copper, the first-mentioned appears to be the most suitable, but it, of course, suffers from the drawback that it corrodes readily in damp atmospheres. The nickel-copper alloy known as Monel metal, however, is practically incorrodible, and as its other physical properties closely resemble those of steel, it has been suggested as a suitable material for safety lamp gauzes. To test the validity of the suggestion, a series of comparative tests of safety lamps with gauzes of steel and Monel metal has been carried out by the United States Bureau of Mines, and the report on these tests by Messrs. A. B. Hooker and R. A. Kearns, recently issued, is entirely favourable to the use of the newer material.

The tests were carried out in the flame lamp testing gallery of the Bureau, the gauzes being mounted in an unbonneted Seippel lamp and placed in a horizontal current of explosive mixtures of Pittsburg natural gas and air. The mixtures used were 6 per cent., 7 per cent., 8·6 per cent. and 11 per cent. of gas, and the tests were continued with each mixture at different velocities, ranging from 1,000 ft. to 1,500 ft. per minute, until the gauzes failed by allowing the flame to pass and ignite the mixture outside the lamp. In some cases, 200-mesh coal dust was added to the gaseous mixture for the last part of the test. With any of the four mixtures used in these tests, it was found that the Monel metal gauzes failed at the same velocity as the steel gauzes did, and it is interesting to note that the velocity causing failure was lowest in the case of the 7 per cent. mixture and highest with the 8·6 per cent. mixture; this was true for both steel and Monel metal gauzes. The addition of coal dust to the gas was found to have no appreciable effect upon the safety of gauzes of either material, and the mechanical strengths of both, after the completion of the tests, were approximately equal; with continued heating, however, the steel gauzes became oxidised and lost some of their strength.

To test the relative resistance to corrosion of the two materials, gauzes were placed for a period of 18 days in a room in which different degrees of humidity, ranging from 25 per cent. to 100 per cent., were maintained. The gauzes were weighed before and after exposure to the humid atmosphere and again after having been cleaned. In the case of a steel outer gauze, originally weighing 68·1 grammes, the loss of weight after cleaning was 167·7 milligrammes, while the weight of a similar gauze of Monel metal, originally weighing 74·67 grammes, was increased by 13·4 milligrammes by the same treatment. Before cleaning, many of the meshes of the steel gauze were completely closed by rust particles, although there was no visible change in the gauzes of Monel metal. The slight increase in weight of the latter, above referred to, was due to a fine coating of oxide or tarnish, which was not removed by brushing, whereas all the oxide formed on the steel gauzes was removed by that means.

From these investigations it is concluded that Monel metal is a very satisfactory material for flame lamp gauzes, since it gives a degree of safety in gaseous and dust-laden mixtures equal to that obtained with steel, and the gauzes also maintain their shape and stiffness under high temperatures equally well. These properties, in conjunction with the fact that Monel metal gauzes do not corrode perceptibly in a humid atmosphere, should give a much longer life to safety lamps so fitted. The Bureau therefore considers that the use of Monel metal gauzes for safety lamps should be encouraged. The serial number of the report from which the above material has been extracted is 2,468, and it is dated April, 1923.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Unemployment among engineers shows a striking decline as compared with six months ago, indicating that if the supply of orders at forges and foundries is erratic in its receipt and uneven in distribution, the gross volume of work on hand has undergone a decided expansion. Furnaces producing basic steel continue to work at full capacity in all the principal centres throughout South Yorkshire, and there is the likelihood of the recommissioning of additional plant which has stood idle for upwards of two years. More Siemens furnaces are operating, and though the expensive electrical steel-making plant could handle many more orders, yet the outlook is improved by the elimination of stocks of standard sizes purchased during the war. Prices of raw and semi-finished materials reflect the changed conditions of the Continental demand. The release of a larger tonnage of coke for home consumption has enabled pig-iron producers to increase their output. The bulk of current production is going away on contract account, but there is an unmistakable tendency to quote easier rates. Thus East Coast hematites delivered in Sheffield are this week offered at 6*l.* 2*s.* 6*d.* compared with 6*l.* 15*s.* to 7*l.* a month ago; Lincolnshire No. 3 foundry pig-iron at 5*l.* 10*s.* to 5*l.* 15*s.*, compared with 5*l.* 10*s.* to 6*l.* in May; and West Coast hematites at the maximum figure of 6*l.* 15*s.*, compared with 6*l.* 15*s.* to 7*l.* a fortnight ago. The advent of slightly cheaper iron has not so far induced makers of mild steel to offer more attractive rates. Consumers point to the recurrence on a small scale of competition from Belgium, but manufacturers are secure in the knowledge that their gross production is mortgaged on contract account for a month to six weeks ahead. Business in bars and sheets continues exceptionally flat. The current official quotation of 12*l.* 10*s.* to 13*l.* for bars is only 5*s.* to 10*s.* higher than the official rate ruling twelve months ago, while the market price for sheets, 15*l.* to 16*l.* per ton delivered, is on the average 10*s.* to 1*l.* below the official quotation for June, 1922. The lighter trades present very few new features, though there is a rather more encouraging inquiry for saws, files, picks, shovels and colliery tools. One firm has booked an order for six Lancashire type boilers, with all accessories, for the Scunthorpe district.

South Yorkshire Coal Trade.—A distinctly easier tone is this week reported in export trade in best steams, though so far official rates remain unaltered, and as collieries are disposing of the bulk of their output on contract account they are not inclined to move precipitately. The home industrial demand is fairly active. Slacks hold an exceptionally strong position, but cobbles and nuts are less in request. Furnace and foundry coke is a steady market despite the decline in export business. Business in house coal is not shrinking quite so rapidly as is usual at this time of the year, owing to erratic weather conditions. Quotations:—Best branch hand-picked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 18*s.* to 21*s.*; Yorkshire hards, 22*s.* to 24*s.*; Derbyshire hards, 21*s.* to 24*s.*; rough slacks, 12*s.* to 14*s.*; nutty slacks, 10*s.* 6*d.* to 12*s.* 6*d.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—As is usual in a falling market buyers are very backward. Transactions that are put through, are on a very limited scale, customers confining their purchases to parcels sufficient for early needs, as they anticipate further reduction in quotations. Thus the present outlook is far from encouraging. At the same time the feeling still prevails that so soon as prices become stabilised, a steady flow of trade will speedily follow. Producers who were behind with their deliveries are rapidly overlooking arrears, and output is quite equal to requirements. No. 1 Cleveland pig-iron is still scarce, but is now obtainable at 127*s.* 6*d.*, though some sellers continue to name 130*s.* No. 3 g.m.b. is 117*s.* 6*d.* to 120*s.*; No. 4 foundry, 115*s.*; and No. 4 forge, 112*s.* 6*d.* All the foregoing quotations are f.o.t. makers' works or f.o.b. Tees.

Hematite.—There is an easier feeling in the East Coast hematite branch. A few inquiries are circulating, and one or two sales to the Continent have been made, but generally business is very quiet. Both for home purposes, and for despatch to foreign destinations, Nos. 1, 2 and 3 are put at 117*s.* 6*d.* No. 1 is at a premium of sixpence to a shilling.

Blast-Furnace Coke.—Durham blast-furnace coke is easier in sympathy with the downward movement in

other descriptions of fuel, but supply continues far from plentiful. Local consumers have to pay round about 44*s.* delivered.

Foreign Ore.—There is little or nothing doing in foreign ore. Best rubio is 24*s.* c.i.f. Tees.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel keep busy on contracts made some little time ago, but they experience no small amount of difficulty in booking orders to follow on work which is fast being executed. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 10*l.*; steel billets (medium), 10*l.* 10*s.*; steel billets (hard), 10*l.* 15*s.*; steel boiler plates, 14*l.*; steel ship, bridge, and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; heavy steel rails 10*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 14*l.*; and galvanised corrugated sheets, 19*l.*

Imports of Iron and Steel.—Interesting statistics issued by the Tees Conservancy Commissioners this week contain returns of imports of iron and steel to the River Tees from Holland, Belgium, France, Norway, Sweden, Germany, and coastwise for the seven months ending May 31 last, as compared with the same months a year ago, and the corresponding pre-war period of 1913–14. The pig-iron brought in during the months just ended amounted to 4,692 tons, as compared with 30,819 tons a year ago, and 181 tons for the 1913–14 period; crude sheets, bars, billets, blooms and slabs unloaded to May 31 last reached 38,276 tons, as against 35,646 tons a year ago, and 27,413 tons for the 1913–14 period; and plates, bars, angles, rails, sheets and joists imported to end of May last amounted to 7,146 tons, as against 3,158 tons a year ago, and 15,124 tons for the 1913–14 period.

Iron and Steel Shipments.—Official returns give the shipments of iron and steel from the Tees during May at 86,042 tons, comprising 32,467 tons of pig-iron, 4,544 tons of manufactured iron, and 49,031 tons of steel. Wales was the largest customer for pig-iron, taking 4,630 tons; whilst the United States received 4,281 tons; Germany, 3,862 tons; France, 3,745 tons; Scotland, 2,360 tons; Finland, 2,180 tons; and Italy, 2,146 tons. As usual India was the heaviest importer of both manufactured iron and steel receiving 2,454 tons of the former, and 9,879 tons of the latter. Among other large importers of steel were: Victoria, 6,552 tons; Japan, 3,712 tons; New South Wales, 3,149 tons; and Egypt, 2,941 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No improvement of any kind can be reported in the steel trade of Scotland, and hopes of better times are now concentrated on the latter half of the year—after the holiday period in July. In the meantime a certain amount of work is going on, but it is mainly confined to contracts fixed up some time ago. New business is extremely scarce, and consists almost solely of the immediate requirements of buyers who are not inclined to order ahead. Ship plates are in very poor demand on account of the low level of shipbuilding, but a fair tonnage of structural sections is going through. In the black steel sheet trade the home demand is not good, but overall the makers are managing to get rid of quite a large tonnage because of orders on hand. Current prices are as follow:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations. Export quotations have an easier tendency.

Malleable Iron Trade.—Conditions in the malleable iron trade of the West of Scotland are no better, and the reduction made in prices last week has not yet brought out much fresh business. A few orders which were being held back in anticipation of easier quotations have now come on to the market, but no large tonnage is likely to be placed so long as general trade is so poor. The steel re-rolling branches are managing to pull along fairly well still, and the output is quite satisfactory when all is considered. The price of "Crown" bars continues at 12*l.* per ton delivered Glasgow stations.

Scottish Pig-Iron Trade.—Scottish pig-iron makers are doing wonderfully well at the moment, but of course the number of furnaces in blast is not large. The steel makers being so quiet the home demand for hematite iron is poor and the price to-day is no better than 6*l.* 5*s.* per ton delivered. Foundry iron is rather dull as the export trade is a bit slower, but as the inquiry from abroad shows some improvement once more, producers are hopeful that as prices are easier they may secure some fresh contracts. Prices have been shaded this week and are 6*l.* per ton for No. 1 quality and 5*l.* 15*s.* per ton for No. 3 quality, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, June 2, totalled 2,230 tons. Of that quantity 2,195 tons went foreign—as against 1,310 tons for the preceding week—and 35 tons went coastwise. For the corresponding week of last year the figures were 1,345 tons foreign and 146 tons coastwise, making a total of 1,491 tons.

Scottish Shipbuilding.—The shipbuilding returns of new tonnage launched during the past month emphasise to some extent the low water mark of the industry at the present time. Not only was the actual output the poorest month since January, but the amount of new work booked was also exceedingly small. The latter was perhaps better overall than during some of the preceding months, but it was nevertheless far from satisfactory. Labour troubles still continue, and so long as the boilermakers are not working there can be no hope of any improvement in the yards. The following are the output figures for the past month and the totals for the year to date:—

	June, 1923.		Five Months, 1923.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	10	17,210	45	137,145
The Forth	2	367	9	7,965
The Tay	1	10,270	3	19,470
The Dee and Moray Firth	—	—	3	2,190
Total	13	27,847	60	166,770

The Clyde total of 17,210 tons for last month is the lowest output for the month of May since the year 1908, and the five months' output of 137,145 tons is also the lowest for the first five months of any year since 1908, with the single exception of last year, when the figures were 46 vessels of 132,587 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The market for steam coals is decidedly easier and new business is less active than it has been for some weeks past. Generally the collieries are well placed with contract commitments, and some have nothing to sell for another month at least. Those with coal for disposal, and they represent the majority, however, experience difficulty in placing parcels as buyers wherever practicable are holding off. Middlemen holding contracts, too, are ready to discount colliery prices by 1*s.* to 2*s.* per ton, and in the circumstances it is difficult to gauge values accurately as there is no doubt that a fair amount of quiet business is passing at prices below those indicated on the market. Colliery owners are now asking no more than 40*s.* for best Admiralty large coals, and 37*s.* 6*d.* for the leading Monmouthshires, but through merchants these prices can be discounted by at least 2*s.* Large dry coals are, however, well sold, and steady on the basis of 37*s.* 6*d.* for the best grades and from 35*s.* for ordinaries. Best smalls, too, are steady at 30*s.*, but the inferior qualities can be secured at from 19*s.* to 24*s.* Anthracite coals continue scarce and firm with machine-made cobbles from 60*s.* to 61*s.* and nuts from 55*s.* to 60*s.* The third shift has at last been brought into operation by the coal trimmers and tippers at the South Wales ports. Only a third of the tips are, however, being worked by night at present, but this is bound to expedite the despatch of vessels, though at the moment the quantity of coal reaching the docks is not sufficient to keep all the appliances fully employed. Still the working of tips by night will in the long run benefit traders for the regular working of collieries is more assured and shipping is likely to secure quicker turns. The new shift starts at 10 p.m. and finishes at 6 a.m., while the morning shift commences at 6 a.m. and ends at 2 p.m., and the afternoon shift starts at 2 p.m. and concludes at 10 p.m., with an half an hour meal time in each shift. Exports of coal as cargo last week amounted to 580,430 tons, of which 270,250 tons went to France, 62,210 tons to Italy, 77,920 tons to South America, 10,650 tons to Spain, 15,650 tons to Portugal, 16,010 tons to Greece, 34,140 tons to British coaling depots, 5,500 tons to Canada, 11,730 tons to Belgium, 12,680 tons to Holland, 28,130 tons to Germany and 35,530 tons to other countries. A block of coal weighing 3 tons 12 cwt. has been hewn, from the collieries of the Albion Steam Coal Company, and shipped to France for exhibition at the Bordeaux Fair. It took two men between three and four days to cut this huge block, which was raised from the pit bottom 600 yards below the surface, in the colliery cage.

Iron and Steel.—Locomotive men and shunters employed at the Llanelly steel works came out on strike on Saturday last for an increase of 15*s.* per week, and by their action threw idle some 3,000 steel workers. Work was, however, resumed to-day, the men agreeing to allow their wage claim to be considered at a constitutional conference to be held at the end of the month. Exports of tin plates and terne plates last week amounted to 8,800 tons, compared with 6,800 tons in the previous week, black plates to 3,270 tons, against 1,400 tons; galvanised sheets to 1,610 tons, against 310 tons; and other iron and steel goods to 6,460 tons, against 1,240 tons.

THE INSTITUTION OF GAS ENGINEERS.—This Institution is to hold its annual meeting this year in Belfast, commencing on June 26 under the presidency of Mr. James D. Smith, M.Inst.C.E., the engineer of the corporation's gas undertaking. This is the centenary year of gas lighting in Belfast, gas having been first supplied to the public there on August 30, 1823.

BUSINESS WITH DENMARK.—The Commercial Secretary at Copenhagen, Mr. R. M. A. Turner, will be in attendance at the Department of Overseas Trade from June 25 to 30, inclusive, and will be pleased to interview, by appointment, United Kingdom manufacturers and merchants interested in export trade to Denmark. Applications for interview should be addressed to the Comptroller-General, Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, reference 7,505 F.R.

THE ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on Tuesday last, the 4th inst., the Duke of Northumberland, president, being in the chair. It was announced that the managers had elected Sir William Bragg, Fullerian Professor of Chemistry, to be director of the laboratory, superintendent of the House, and director of the Davy Faraday Research Laboratory, in succession to the late Sir James Dewar.

NOTICES OF MEETINGS.

THE INSTITUTION OF CHEMICAL ENGINEERS.—Friday, June 8, at 5 p.m., at the Engineers' Club, 39, Coventry-street, W. 1. Annual Corporate Meeting. Paper on "Industrial Oxygen," by Mr. T. C. Finlayson, B.Sc. At 8 p.m., Informal Dinner.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, June 9, at 2 p.m., in the Lecture Hall of the Institute, Newcastle-upon-Tyne. "The Permian Formation in East Durham," by Mr. W. O. Wood: "Vertical and Lateral Variations in the Composition of Bituminous Coal Seams," by Professor Henry Briggs, B.Sc., Ph.D.

THE OPTICAL SOCIETY.—Thursday, June 14, at 7.30 p.m., at the Imperial College, Imperial Institute-road, South Kensington, S.W. 7. Papers to be read and discussed: "Levels and Level Bubbles," by Mr. S. G. Starling, A.R.C.Sc., B.Sc., F.Inst.P.; "A New Form of Balloon Theodolite," by Mr. T. F. Connolly, M.Sc.; "The Primary and Secondary Image Curves formed by a Thin Achromatic Object Glass with the Object Plane at Infinity," by Mr. E. Wilfred Taylor.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, June 15, at 9 p.m., a discourse will be delivered by Sir Ernest Rutherford, LL.D., D.Sc., F.R.S., M.R.I., Professor of Natural Philosophy. The subject is "The Life History of an Alpha Particle from Radium." Afternoon Lecture, at 3 p.m.: Saturday, June 16, Sir Ernest Rutherford, LL.D., D.Sc., F.R.S., Professor of Natural Philosophy, on "Atomic Projectiles and their Properties" (Lecture VI).

THE ROYAL SOCIETY OF ARTS.—Friday, June 15, at 4.30 p.m. Sir George Birdwood Memorial Lecture, "The Influence of Race on Early Indian Art," by Sir John H. Marshall, C.I.E., M.A., Litt.D., F.S.A., Director-General of Archæology in India. The Most Honourable the Marquess Curzon of Kedleston, K.G., G.C.S.I., G.C.I.E., P.C., F.R.S., Secretary of State for Foreign Affairs, will preside.

THE AIRCRAFT YEAR BOOK.—A copy of a new year book of useful information of an international character, and relating to the aeronautical industry, has been forwarded to us from the publishers, Messrs. Sampson Low, Marston and Co., Limited, 100, Southwark-street, S.E. 1. The year book, which has been edited by Mr. C. G. Grey and compiled by Mr. C. E. Lee, contains a list of aerial transport companies, aircraft manufacturers, and other concerns connected with the aircraft industry in all parts of the world, and also includes lists of clubs and institutions, air lines, publications relating to aircraft, &c. Illustrations are included of some types of aircraft used for transport purposes and particulars are also given of most of the aircraft engines in common use. For reference purposes the world's aviation records are given and the text of the international convention for the regulation of aerial navigation is also reprinted. There is a brief glossary of aeronautical terms, and articles on the transport of mails, aerial stamps and photography from aircraft, have been contributed by specialists. The book is strongly bound in cloth-covered boards and its price is 6*s.* net.

LIVERPOOL MEETING OF THE BRITISH ASSOCIATION—SCIENTIFIC EXHIBITION.—The British Association for the Advancement of Science will hold its ninety-first annual meeting at Liverpool in the week, Wednesday, September 12, to Wednesday, September 19, under the presidency of Sir Ernest Rutherford, F.R.S., of Cambridge. Most of the sections will be accommodated in the University buildings; the reception room will be in St. George's Hall, Lime-street. In addition to the sectional proceedings and to the general and special excursions arrangements are being made for a scientific exhibition to be held in the Central Technical School, Byrom-street, which is close to St. George's Hall. The leading manufacturers of scientific instruments and apparatus have promised to exhibit their latest novelties and prominent specialities, and the exhibition, the first of its kind, it is hoped, will be one of the great features of the meeting, and of unprecedented completeness and great importance in itself. Members of the British Association will have free access, and the public will be admitted at a small charge; the exhibition will be open for the period, September 10 to 22. Mr. F. W. Bain, of the United Alkali Company, Cunard Building, Liverpool, is chairman of the Exhibition Committee, to whom inquiries should be addressed. A good Liverpool meeting may confidently be predicted, and early application to the secretary of the British Association, Burlington House, W., is advisable. Reduced railway fares will once more be granted to intending members on their presenting a voucher signed by the secretary of the Association. The presidents and recorders of the sections in which we are particularly interested are: Section G, Engineering, Sir Henry Fowler, K.B.E., and Professor G. W. O. Howe, the University, Glasgow; Section A, Mathematics and Physics, Professor J. C. McLennan, F.R.S., of Toronto, and Professor A. O. Rankine, Imperial College of Science and Technology, South Kensington; Section B, Chemistry, Professors F. C. Donnan, F.R.S., University College, London, and Professor C. H. Desch, the University, Sheffield. Inquiries as to papers and sectional proceedings should be addressed to the recorders. The programme will be issued in August. Among the subjects to be discussed in the Engineering Section are "Transport and its Indebtedness to Science" (Sir H. Fowler's presidential address), the teaching of dynamics, vocational training of the engineer, and cohesion and molecular forces.

EXHIBITS AT THE MINING EXHIBITION AT THE AGRICULTURAL HALL.

CONSTRUCTED BY THE SULLIVAN MACHINERY COMPANY, LONDON.

(*For Description, see Page* 711.)

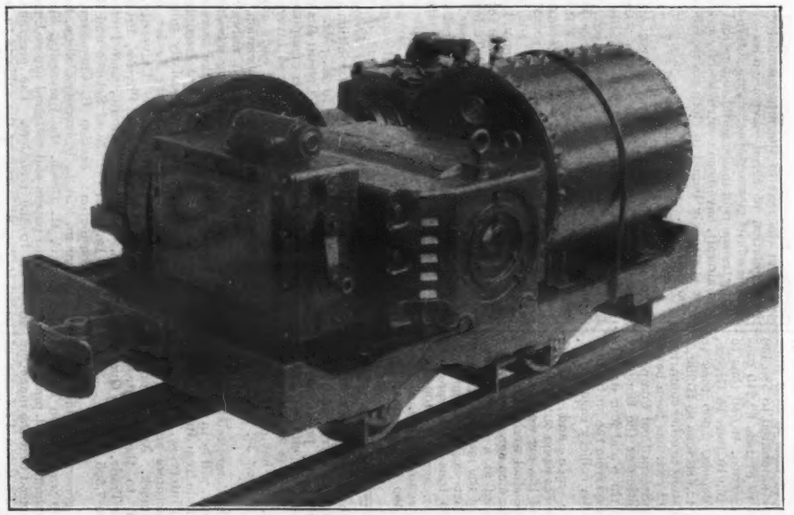


FIG. 12. PORTABLE TOTALLY-ENCLOSED MINE CAR AIR COMPRESSOR.

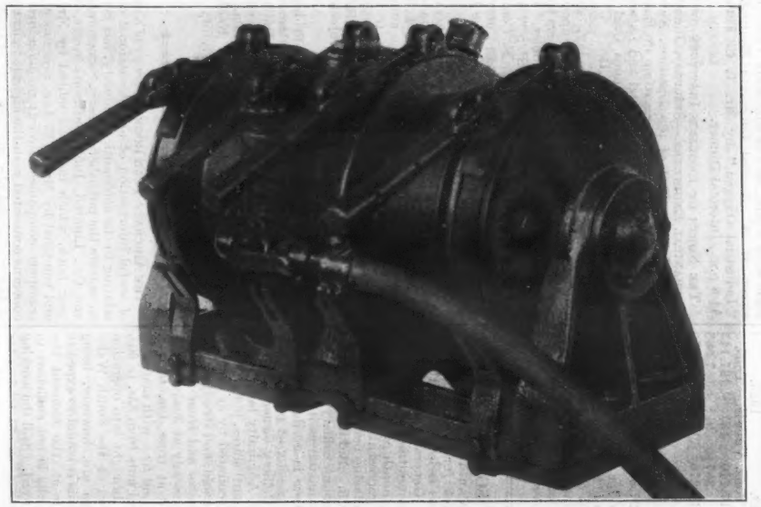


FIG. 13. DOUBLE-DRUM HOIST.

FIG. 14.

FIGS. 14 AND 15. HOISTS ON HAULAGE WORK IN MINES.

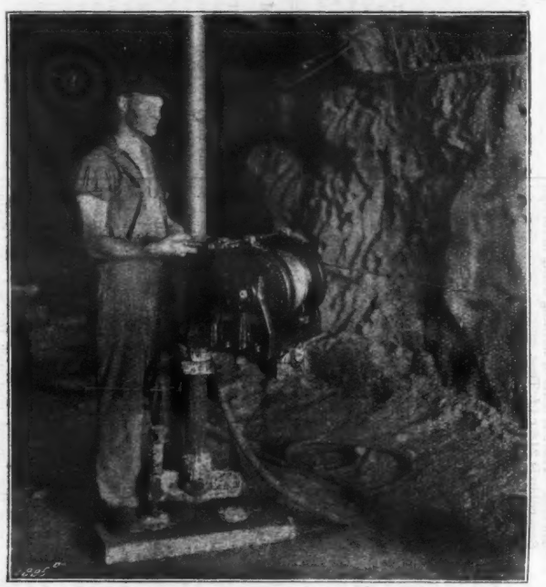


FIG. 15.

THE DIESEL ENGINE WORKS OF MESSRS. HARLAND AND WOLFF, LIMITED, GLASGOW.

(*For Description, see Page* 702.)

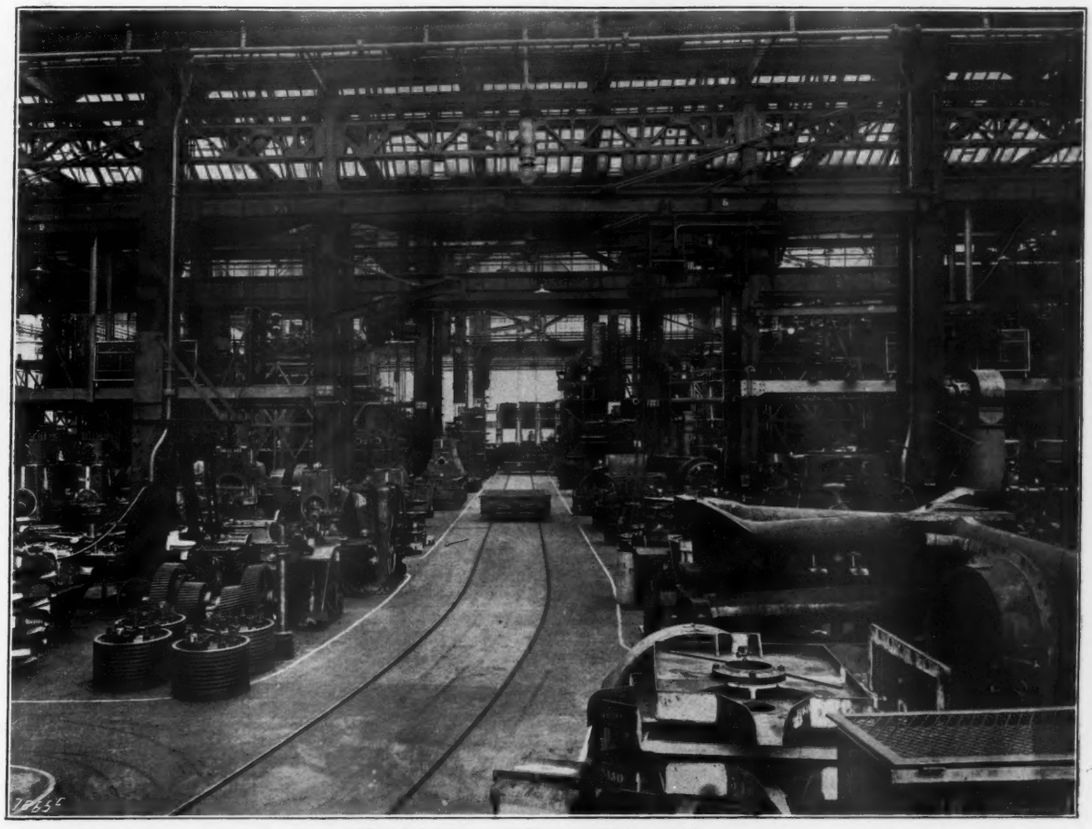


FIG. 1. GENERAL VIEW IN ERECTING SHOP.

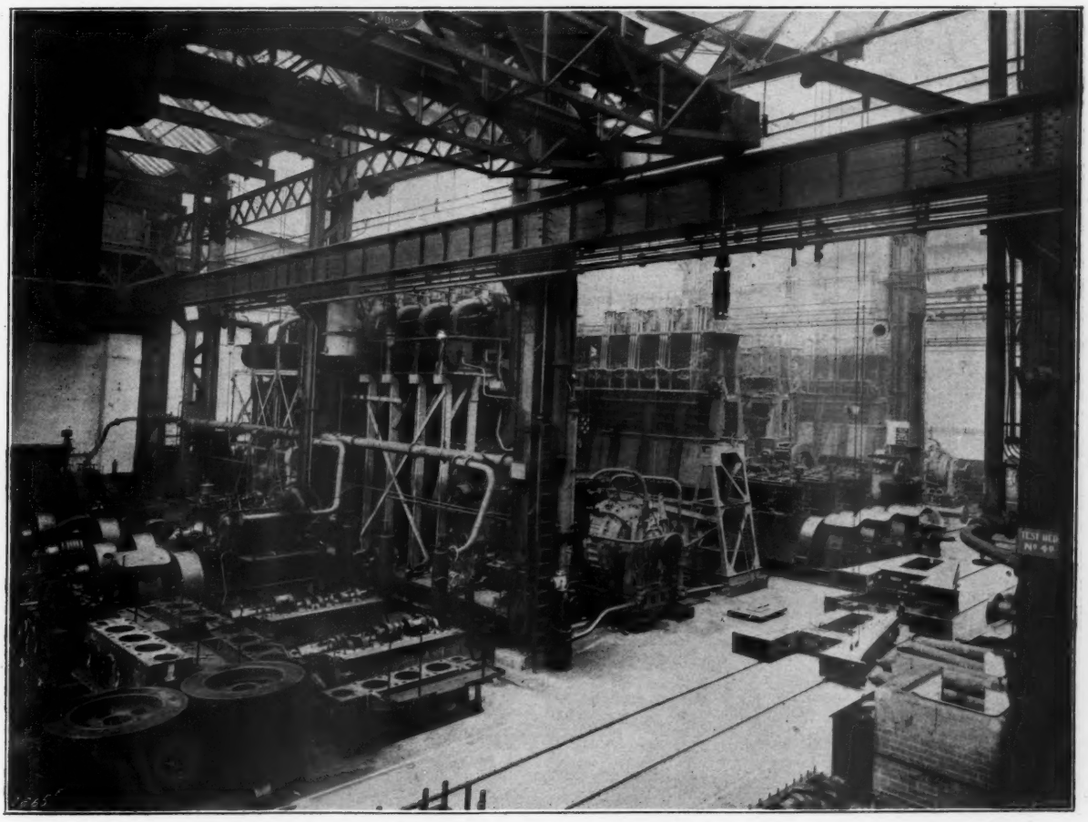


FIG. 2. ASSEMBLING AND TESTING BAY.

(*To face page* 702.)

THE DIESEL ENGINE WORKS OF MESSRS. HARLAND AND WOLFF, LIMITED, GLASGOW.

(*For Description, see Page* 702.)

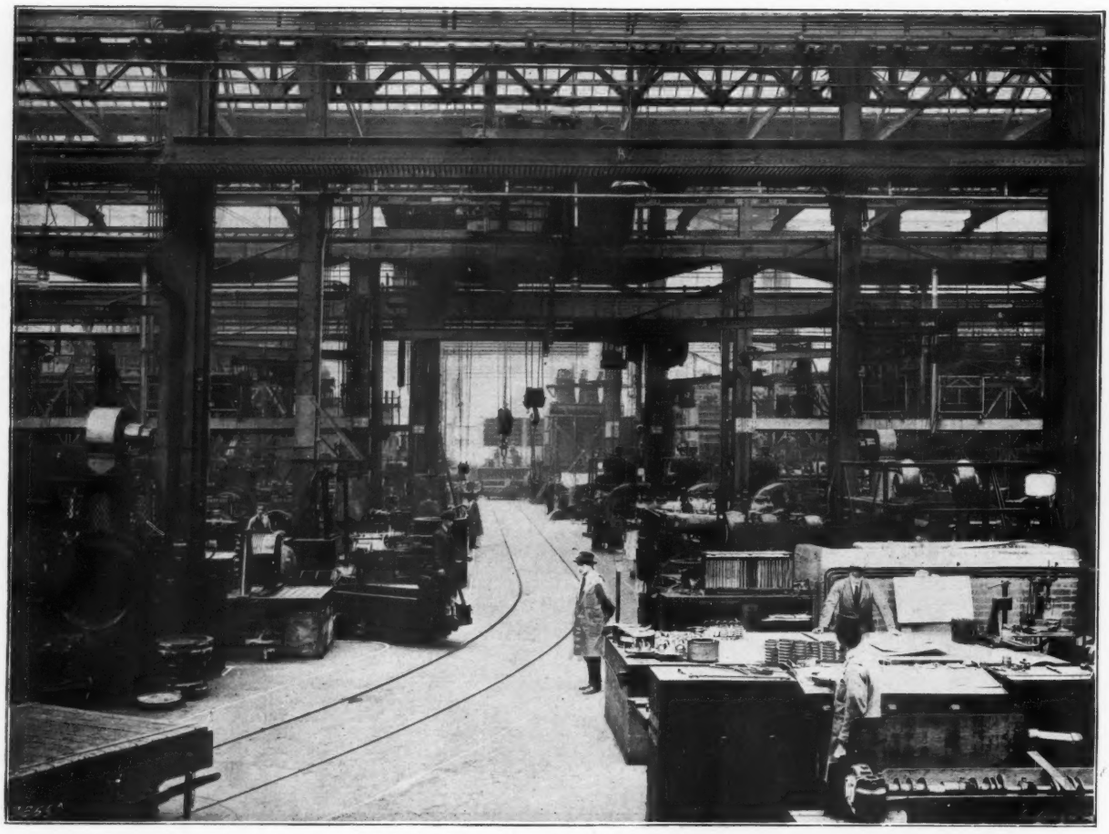


FIG. 3 FITTING AND ASSEMBLING SHOPS.

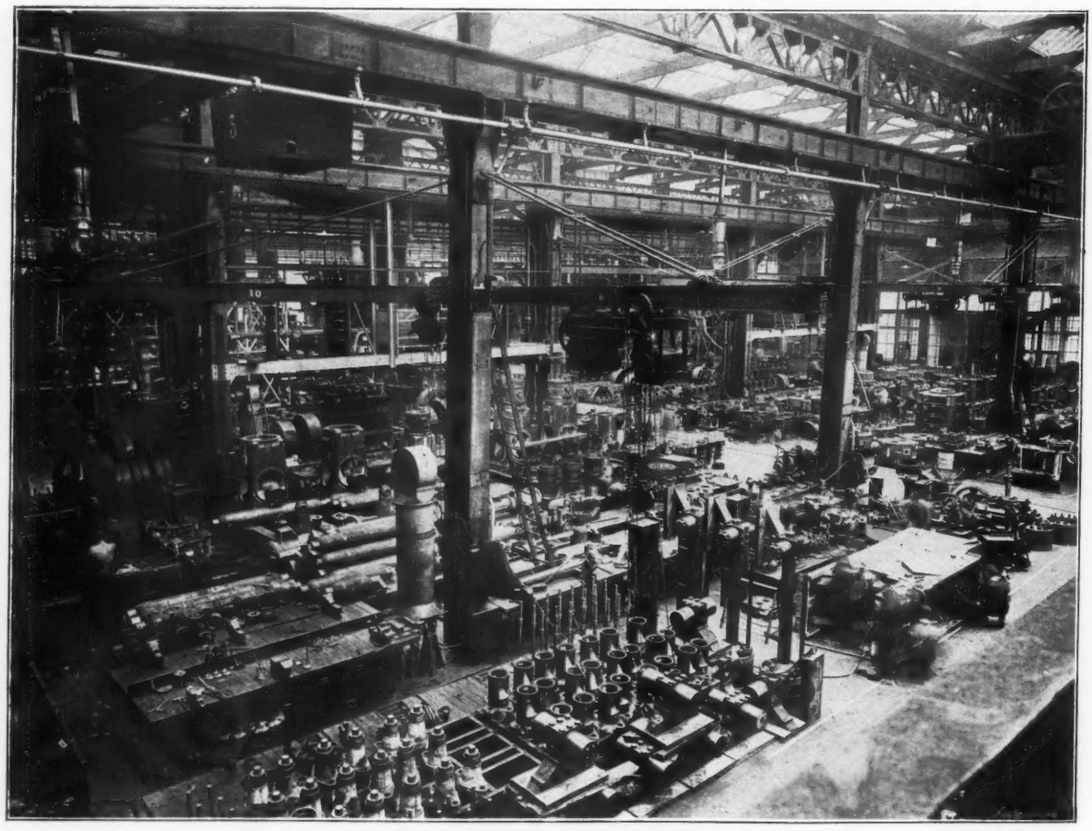


FIG. 4. GENERAL VIEW IN ENGINE SHOP.

THE DIESEL ENGINE WORKS OF MESSRS. HARLAND AND WOLFF, LIMITED, GLASGOW.

(*For Description, see Page* 702.)

FIG. 5. ENGINE MACHINE SHOP, BAY 8.

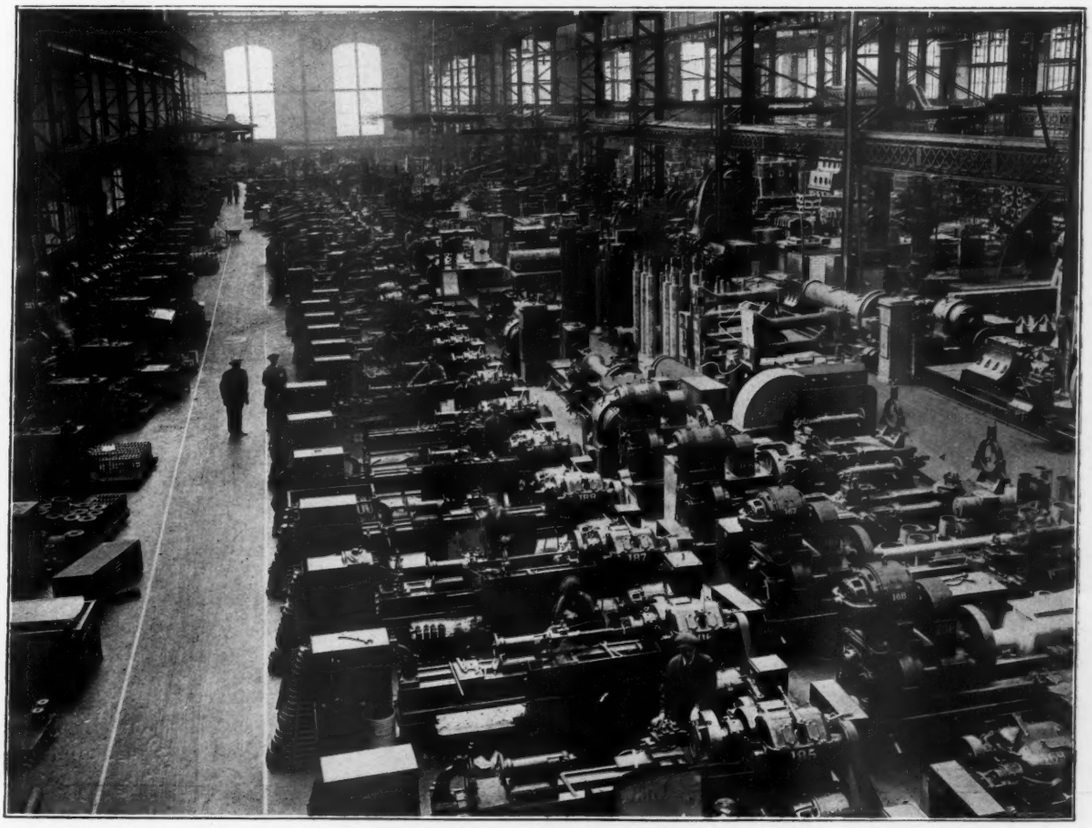


FIG. 6. ENGINE MACHINE SHOP, BAY 9.

THE TRAFFORD WHARF ON THE MANCHESTER SHIP CANAL.

MR. H. A. REED, M.INST.C.E., CHIEF ENGINEER TO THE MANCHESTER SHIP CANAL, ENGINEER;
MESSRS. KIRK AND RANDALL, LIMITED, LONDON, CONTRACTORS.

(*For Description, see Page* 703.)

FIG. 1. GENERAL VIEW OF TRAFFORD WHARF.

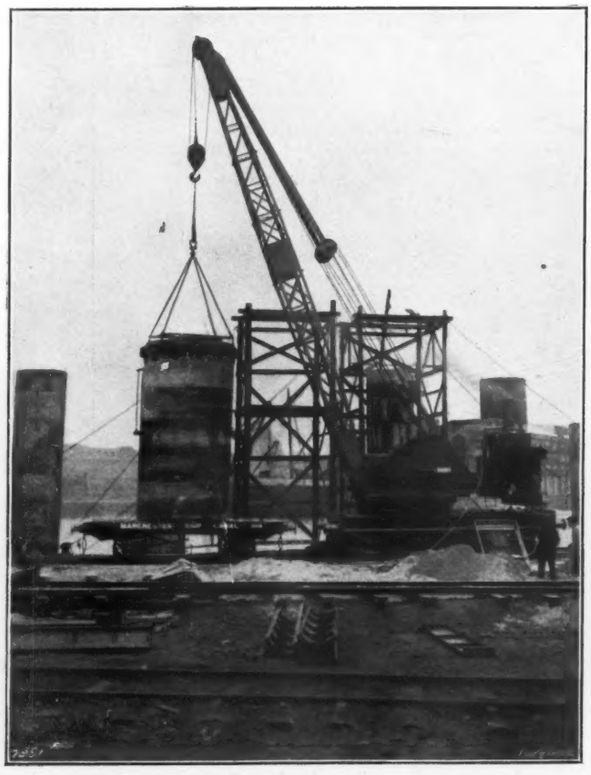


FIG. 2. REMOVING REINFORCED CONCRETE CYLINDER.

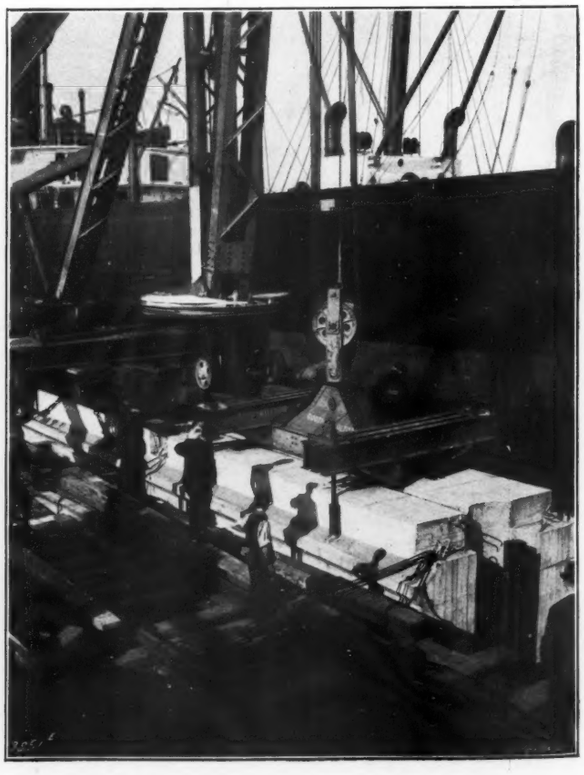


FIG. 3. PLACING A REINFORCED CONCRETE BOX IN POSITION.

(*To face page* 703.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

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Three One-Page Plates.—THE DIESEL ENGINE WORKS OF MESSRS. HARLAND AND WOLFF, LIMITED, GLASGOW.

One One-Page Plate.—THE TRAFFORD WHARF ON THE MANCHESTER SHIP CANAL.

ENGINEERING.

FRIDAY, JUNE 8, 1923.

POWER PLANT PATHOLOGY.

SOME cynic has defined gratitude as a lively sense of favours to come; a certain *soupçon* of such an expectation warms our welcome of a renewed issue of the masterly reports on machinery failures which were issued yearly up till 1910 by Mr. Michael Longridge, of the British Engine, Boiler and Electrical Insurance Company, Limited. These reports were, we learn, autographs, being the personal production of Mr. Longridge himself, and owed their value largely to his exceptional experience and entire absence of *partis pris*. Their author had no recondite theories to air nor was he concerned to exhibit his erudition or his familiarity with foreign technical literature. He did not offer us *rechauffés* of the views of Dr. Ing. X, or of the theories of Herr Professor von Y, concerning breakdowns in East Prussia or Poland, but he told us straightforwardly that which he himself did know, and he had the artist's gift of selecting from amongst multitudinous data those which were of real value and importance.

It is not surprising, therefore, to read in the introduction to the new report dealing with the experiences of the year 1922, which has just been issued by the above-named company that the discontinuance of the series aroused world-wide lamentations and reproaches. Unfortunately, limitations due to increasing years, have prevented Mr. Longridge from taking any predominant part in compiling the new issue, but he has established a standard and a tradition, which will undoubtedly guide his successors.

Perhaps the most interesting feature in the new report are the particulars given of steam turbine failures. Hitherto details as to catastrophes of this kind have appeared in American journals only. In this country such particulars seldom become public property unless the accidents result in loss of life. Hence although it is known that there have been a number of burst discs, authoritative data have been lacking, whilst in America, although at times the technical press has accepted makers' absurdities to the effect that such accidents were due neither to faulty material nor bad workmanship or design, yet the details given have been sufficient to enable engineers generally to form an independent opinion.

There was no possibility in this country of an improvement in this regard until the insurance companies were prepared to accept turbine risks. The director of a company being in a *quasi* trustee position dare not make ventures which he might willingly undertake if he was responsible to himself alone. It will be remembered that a similar condition of affairs arose in the infancy of electric lighting, and during the early days of the war no company would insure air raid risks, which were, however, freely accepted by Lloyds. Our would-be social reformers were they not constitutionally impervious to unpalatable facts, might realise from such historical items that the individual capitalist is a more important factor in industrial progress than is his mere capital or, indeed, than is labour. Now that the turbo-generator is no longer a novelty, the insurance companies feel justified in accepting them for insurance, and it is to this that we owe some of the most interesting paragraphs of the report above mentioned.

It is true that the very large turbo-generators now being built necessarily involve the transcending of past experience, and their adoption is accordingly not devoid of some special risks. Twenty years ago the standard speed for a 3,000-kw. machine was 750 r.p.m. To-day we have 5,000-kw. machines running at 5,000 r.p.m., whilst machines running at 3,000 r.p.m. have developed over 12,000 kw. The extraordinary output now obtained from small weights of metal, have necessitated many innovations in generator design, and have involved some reduction in their efficiencies. Makers were prepared to guarantee efficiencies of 97 per cent. in the case of a 3,000-kw. alternator running at 750 r.p.m., but with the outputs now demanded the generator losses aggregate nearer to 5 per cent. than to 3 per cent. of the output of the machine. Special arrangements have had to be made for cooling the coils, and it is very essential to fit reliable air filters. Several cases of generator failure are recorded in the report as originating in dirt deposited from the air used for cooling the machines.

The main mechanical troubles have arisen at the end coils and fittings, and two very large machines were put out of service by a failure of the insulation round the bolts holding the core segments together. In this case the builders came to the conclusion that the trouble originated in a synchronism between the natural periodicity of the bolts when tightened up and the frequency of the machine. In making good the damage, therefore, arrangements were made to dispense with bolts passing through the cores. It is very unfortunate that all insulators are such poor structural materials from the mechanical standpoint.

The worst turbine accidents were disc failures, of which two are illustrated in the report. In the one case a large segment broke out of the first wheel of a 5,000-kw. turbine running at 3,000 r.p.m. The wheel was 55½ in. in external diameter, and was operated with steam at 200 lb. per square inch gauge pressure and with 100 deg. superheat. The smash is attributed to disc vibration, and is thus comparable to the accidents reported in the American technical press. There, however, it has generally been a low-pressure wheel that has failed, but here it was, as stated, the first wheel which went, although it was relatively lightly stressed. It was also the first wheel which fractured in the second case reported. Here quite a small sector broke out of the rim, and as before disc vibration is held to be the responsible cause. In this instance, it is believed that the vibration was induced by the fact that the wheel was working with partial admission.

There is no doubt some difficulty in effecting a satisfactory compromise in proportioning turbine discs. Under modern conditions of high speeds of rotation it is very important to keep the shaft short between bearings so as to ensure a critical speed well above the running speed of the shaft, and for the same reason it is desirable to keep down the weight of the wheels to a minimum as, unlike a drum, they add nothing to the stiffness of the rotor, but by their weight merely lower the critical speed of rotation. There is thus a temptation to make the discs very thin, so that in many cases the natural

periodicity of these discs, as vibrating elastic bodies, has coincided with the running speed of the machine. If made stiffer, however, the added weight lowers the critical speed of the shaft, so that a happy compromise between alternative dangers is not altogether easy.

In a third case a disc cracked at the hub, because it was too easy a fit on its shaft. Under the centrifugal stresses, the bore enlarged so that whilst running, the disc was loose and a badly-fitting key accounted for the rest. One ingenious plan of avoiding looseness whilst running without necessitating excessively hard forced fits, is to make the hub bear on its shaft at the ends only, the middle standing clear of the seat. With hubs of this type suitably proportioned the centrifugal stresses cause the bore to assume a barrel-shaped form, the centre expanding whilst the end diameters actually tend to be diminished by the stress. The theory of this action is the same as that of the "Spence humps" developed in short boilers, tested under hydraulic pressure, a phenomenon which was fully discussed in ENGINEERING* over thirty years ago. The only accident reported to a reaction turbine did not even result in a breakdown, as the damage was discovered when the turbine was opened up for ordinary examination. It was then found that owing to wear of the bearings the rotor had fouled the lower half of the stationary blades. Some of these were therefore loosened and caused to protrude $\frac{1}{8}$ in. to $\frac{5}{16}$ in. out of their grooves with the result that the shrouding was nearly worn through. The damage was clearly attributable to faulty lubrication and the failure of a Michell thrust bearing on another unit may be safely attributed to the same cause. It is not enough to supply a sufficiency of oil to a Michell bearing, but it is equally necessary to ensure that each part receives its fair share. Practically every trouble hitherto experienced with Michell bearings has been traced to defective lubrication, and has disappeared when the defects were made good.

Errors in the design and construction of large steam turbines are being steadily eliminated, but the report holds out little hope for the future of the giant internal-combustion engine. "It seems impossible, with the materials available to design breech ends for the larger gas engines, especially when using a rich gas fuel, in such a way as to ensure freedom from these troubles." The trouble to which the foregoing quotation has reference are the cracking of cylinders and liners. Other serious troubles have arisen both with gas and steam engines from the not uncommon practice of supporting the shaft on three bearings. If one settles, or if the wear is unequal, the shaft may be subject to very severe stresses quite unanticipated by its designer. The report states that it is not uncommon when making inspections of shafts and bearings to find that the bottom brass of the centre bearing can be turned quite easily by hand, thus showing that it is carrying none of the weight of the flywheel. A simple and ingenious plan of detecting this defect before matters become serious is described in the report. The crank is raised to its topmost position and the width of the gap between the cheeks measured by a micrometer. The shaft is then revolved through 180 deg. and the measurement again made. If it proves less in this position than in the other it is clear that the shaft is running with a bent centre line, and the bearings require relevelling. Quite a number of failures arise from fastenings working loose, and it would seem that engine builders generally might study with advantage the precautions taken to avoid such defects in motor car and aero engines. In these the high speeds subject the security of fastenirgs to an exceptionally severe test.

A notable point in the section of the report devoted to steam engine practice is the age of many of the engines mentioned. One dated from 1854, and several were built in the "sixties." Their record seems quite as good as that of more modern engines, but it should be remembered that not only were speeds and pressures lower, but it is only particularly well-designed and carefully constructed engines which would have endured to this date. An impassioned but probably Hibernian orator declaiming against jerry-building once demanded to be shown edifices of recent erection which had lasted as long as those which had come down to us from antiquity, and the engineer of to-day would be as helpless in the face of such a request as his architectural *confrère*. Even if we put the proper interpretation on the above "bull," it is unlikely that modern engines will have as long a life, measured in years, as their predecessors; but if life be measured by work accomplished rather than by length of years, the modern prime mover need not fear comparison with earlier engines. Certainly both workmanship and materials have steadily improved, and the average standard has perhaps been raised even more than the highest. Without this improvement the high speeds which have made it possible to generate power in perhaps one-tenth the space needed for plant of equal capacity sixty years ago would have been impossible.

* See ENGINEERING, April 27, 1891, page 468.

RADIATION.

As is now generally known, physicists are to-day without any satisfactory theory as to the nature of light. At the Royal Institution on Friday last Professor H. A. Lorentz, of Leyden, who ranks amongst the very first of our leading physicists, gave an exceedingly clear *exposé* of the present state of affairs in this department of research.

Professor Lorentz said that one of the chief lessons derived from a study of the history of science was that we must not be too soon satisfied with our theories. Progress never lay along a straight line, but we had to seek out our way by trying one path after another, and sometimes we had actually to retrace our steps. Hence ideas regarded as abandoned for ever, had, at times, to be taken up and re-examined. This might be illustrated by our present views as to how light was emitted and radiated. Concerning this, two theories had been developed—the corpuscular theory by Newton and the undulating theory formulated by Hughens and perfected nearly a century later by Young and Fresnel, and this was subsequently brought into accord with electromagnetic theory by Clerk Maxwell. It appeared nevertheless that the two theories were closely interwoven in the ideas of Newton, and it might well be that they would be interwoven again in the near future.

In Newton's Optics his corpuscles were regarded as moving in straight lines so long as they were not subjected to a deflecting force, and it was to such a deflecting force that Newton attributed the diffraction phenomena discovered by Grimaldi, who had noted that the shadow of a wire was in certain conditions wider than it should be, were the rays wholly rectilinear. To explain this Newton assumed that on passing very close to the wire the corpuscles were repelled by it, and along similar lines he was able to frame an explanation of the reflection and refraction of light.

He pointed out that we must not take it that the corpuscles striking a mirror were reflected by the individual molecules of the surface. Under a magnification sufficient to make visible the individual molecules it would be seen that the reflecting surface was really very rough. Hence if the corpuscles were reflected by individual molecules we could not get regular specular reflection. Hence Newton supposed that his corpuscles were subjected to forces exerted by particles of the glass containing a great number of molecules. This might be true even if the forces in question were sensible only at very small distances. Thus if we supposed the distance at which the particles could act was not more than $\frac{1}{1000}$ mm., and assumed that a corpuscle was at half the distance from the surface, then in describing a small path in the glass the corpuscle would be acted on by innumerable molecules, so fine-grained were these in comparison with the distance stated. There was in this view some resemblances to Laplace's theory of capillarity, which he attributed to the action of forces which became sensible only at insensible distances.

Inside of glass, or in air, the corpuscle was, Newton held, acted on by balanced forces coming from all directions, and having accordingly no resultant. Once inside the glass, therefore, the corpuscle would move with constant velocity along a straight line, being deflected only as it passed through a thin layer on both sides of the surface separating the air from the glass.

In this thin layer only, was there a resultant force, which might be due to a difference in the attractions or repulsions of the two surfaces, viz., that of the glass, and that of the air. In that case the resultant would be perpendicular to the surface, and hence any motion the corpuscle had, parallel to the surface would be unaffected, the component of motion perpendicular to the surface being alone changed, and this would remain true whether the particle were reflected or transmitted.

In this way Newton was able to give an easy explanation of the laws of reflection, and without much difficulty also of the laws of refraction. Thus, referring to Fig. 1 on page 719, let A B represent a glass surface and v_1 the path and velocity of a corpuscle or train of corpuscles moving through the air, whilst let v_2 represent the velocity of the corpuscles inside the glass. Then if z and i denoted the angles of incidence and refraction we had (since the horizontal component of the motion was unchanged),

$$\frac{\sin i}{\sin z} = \frac{v_1}{v_2}$$

so that the ratio of the sines was in the inverse ratio of the two velocities, and the laws of refraction would be satisfied by this hypothesis if the velocity of light was the same in whatever direction it moved.

Luminous bodies emitted light always with the same velocity, so that v_1 was constant. From this constancy we could deduce the constancy of v_2.

The potential energy of the corpuscle was different in the glass from what it was in the air, and this difference was constant, and therefore the difference between the kinetic energies of a corpuscle in the two media was also constant; that was to say that $v_1^2 - v_2^2 =$ constant, so that if v_1 was constant so also was v_2, and the law of refraction was explained.

Proceeding, the speaker said that he might follow further Newton and his successors, who had made this emission theory one of the most beautiful ever proposed. It was indeed a very great pleasure to read Newton's Optics; Hamilton's "Systems of Rays" would, however, he thought, be too technical for discussion that evening.

Newton devoted much thought to the question of vibrations, and even to that of waves and their propagation. To this he had been led by his very careful examination of the colours of thin plates, producing them with the layer of air confined between a flat plate of glass and a convex lens below it. The "rings" he found were visible both by reflected and by transmitted light, but the bright rings seen by transmitted light had the same diameter as the dark rings seen by the reflected light. This followed naturally, for if much light were transmitted there was little left to reflect.

Taking the upper of the two glass surfaces as plane, all the corpuscles on passing through this should from symmetry be in the same condition, yet at the opposing surface some were reflected and some transmitted. There must be a cause for this, and of a periodic character as indicated by the alternation of the light and the dark rings. Newton supposed, therefore, that whilst passing between the two surfaces the corpuscle was in a special state, being alternately in a "fit" of easy transmission and a "fit" of easy reflection. Whether these fits were due to a kind of circular, vibratory or wave action, Newton said he did not then stop to inquire, but suggested that those who needed an hypothesis might suppose that the corpuscle on striking a surface threw it into waves like a stone striking stagnant water or as sound waves did when they impinged on a body. Then when any ray met the surface at a point where the motion of the latter "conspired" with the motion of the corpuscle, we might have easy transmission and conversely, "Whether true or false, we do not," said Newton, "here consider," and he contented himself with the view that in some way or another the corpuscles possessed these alternating fits of easy transmission and easy reflection. He explained also by this hypothesis, the fact, that part of the incident light was always reflected at a glass surface. If there were no difference between the corpuscles we would expect that all or none were reflected or transmitted.

The fits could not, he thought, be produced at the surfaces, but must be derived from the very source itself where there must accordingly be something like a vibration. Newton, therefore, had no objection to vibrations, but nevertheless his theory was a corpuscular one. He never thought of the ray itself being a wave in some medium. With him the corpuscles were equivalent to flying balls, which, when they struck a refracting surface, threw it into vibration like a stone flung into stagnant water.

We now knew that in refraction the ratio of the sines of the angles of incidence and refraction vary directly as the speed of light in the two media, and not inversely as required by Newton's hypothesis. This experimental result was fatal to Newton's theory, and was in agreement with the undulatory theory.

Thus in water, which for ordinary light had a refractive index of $\frac{4}{3}$, the speed of light in water was found to be $\frac{3}{4}$ that of its speed in air, whilst in Newton's theory it should be $\frac{4}{3}$.

As a consequence the undulatory theory reigned supreme until ten or twenty years ago, when other experiments on light led to ideas which, though not exactly the same as Newton's, had a certain resemblance thereto, in that they attributed to light some corpuscular attributes.

According to the electromagnetic theory a beam of light had momentum just as a material projectile had. In the latter case the momentum was denoted by $m\,v$, where m was the mass and v the velocity. When we attributed momentum to a beam of light we meant that it had the same power of setting bodies in motion as a projectile had. That this should be the case was recognised by Clerk Maxwell, and experimental proof was obtained many years later by Ledebur and Hull and Nicholls, who found not merely that light did exert a pressure, but that the intensity of this pressure was in agreement with Maxwell's theory. Light having this momentum resembled in this regard a string of corpuscles.

If it impinged perpendicularly on a perfect mirror a certain force must be exerted to keep the mirror from moving. This pressure had been measured as also had the intensity of the incident beam which was defined as the energy received by the mirror in unit time. We could, therefore, determine the ratio of the two, and we might imagine the results of such an experiment being discussed by a Neo-Newtonian and by a follower of Clerk Maxwell. Both would agree that the momentum of the incident beam was reversed by the reflection, so that the pressure was equal to twice the momentum destroyed in unit time and, as stated, the ratio of this pressure to the energy reaching the mirror in unit time had been measured. The Neo-Newtonian would express this ratio as :

$$\frac{2\,m\,v}{\frac{1}{2}\,m\,v^2} = \frac{4}{v},$$

where the numerator represented the momentum of the corpuscles reaching the mirror and the denominator their kinetic energy. On the other hand the modern physicist would, following Clerk Maxwell, make the ratio equal to $\frac{2}{v}$.

Actual measurement decided the matter against the Neo-Newtonian, and if the latter knew only the classical mechanics his case was hopeless. If, however, he were versed in the mechanics of relativity he would see a way of escape. He would know that when bodies moved at speeds approaching that of light both the momentum and the kinetic energy could no longer be expressed as $m\,v$ and $\frac{1}{2}\,mv^2$ respectively, but by more complicated expressions, and making the necessary corrections he would get exactly the same value for the ratio of the pressure of radiation to its energy as did the follower of Clerk Maxwell.

The Neo-Newtonian would, on these lines, be accordingly able to maintain his position and might fairly be proud of his success. Nevertheless the adoption of the doctrine of relativity would also imply that the corpuscles were of a very strange kind, for if of finite mass their energy would be infinite when moving with the speed of light, and this could not be admitted. The only way of escape open to the Neo-Newtonian, would therefore be to assume that the corpuscles had no mass, but this would not forbid them to have momentum and energy. In that case, however, they would be quite different from the corpuscles imagined by Newton, but would become what were now known as light quanta.

These were more or less like, but not very like, Newton's corpuscles. The term quantum was used in this connection in two different senses. In the one sense it merely implied that the energy of a ray of light was proportional to its frequency; that was to say that the energy of a ray was done up into bundles each equal to $h\,n$, where n was the frequency of the ray and h Planck's constant. In all this nothing was said as to the space occupied by a quantum. On Bohr's theory of the spectral lines each individual ray of given frequency was emitted in separate quanta, each representing the same amount of energy. The energy in a quantum was greater, the greater the frequency of the light, so that the quanta constituting a ray of red light contained individually less energy than the quanta constituting blue light.

Suppose we kept a tuning fork in vibration by successive blows, each of the same strength, and

Fig. 1.

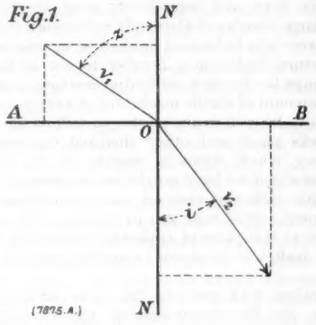
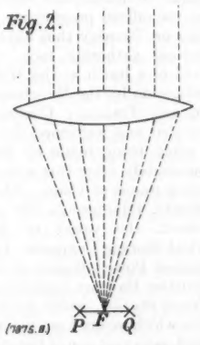


Fig. 2.



allowed time for the whole of the energy of each blow to be radiated off as sound waves before the next blow fell. Then in this case we might also say that the sound was being emitted in quanta. Such quanta as these, however, would spread out as the sound travelled away from the source, and this brought us to a second meaning of the quantum of light.

According to this the energy of each quantum was concentrated into an exceedingly small space, and remained thus concentrated into the same space no matter how far the quantum travelled.

The idea of these concentrated quanta arose from the study of photo-electricity. Thus if light of proper wave-length was allowed to fall on a suitable surface, it was found that electrons were set free and went off from the surface at a certain speed, and with a certain kinetic energy. In the simplest case this energy was exactly equal to that of one quantum of the incident light. This could be easily understood if the ray of light consisted of concentrated quanta, but if these quanta spread over a considerable space it would not be possible for the tiny electron to absorb all the energy of the quantum. Further, it was found that if the distance between the plate and the light source was increased, the number of electrons emitted was reduced in the same proportion as the intensity of the illumination, but the electrons that did come out had the same speed and kinetic energy as before. This would be understandable on the corpuscular theory, or if light consisted of concentrated quanta which retained their individuality, since no matter how far the target was away they would then reach it with the same velocity and the same energy as if near by.

Physicists would like to have these concentrated light quanta or modernised corpuscles to explain photo-electric effects, but concentrated quanta could not be reconciled with Maxwell's equations, which would not permit of the energy of radiation being confined within small spaces. Some would say that we should never swear by a theory, even if Clerk Maxwell's, and that if we must swear, let it be by experiments only. Then, however, it was found that there was the greatest difficulty in explaining experiments on interference in terms of light quanta. We could never get interference between light emitted from two independent sources. The phases of the vibrations emitted from one source were quite independent of those emitted from the other, and when a surface was lighted by two such sources we merely got additional illumination.

Again, since every source emitted quanta in succession and irregularly oriented, we could not have interference between successive quanta, and each interference must accordingly be explained as due to one and the same quantum. Now interference still took place when the difference in phase was as much as 1,000,000 wave lengths. Hence, to get interference it would be necessary for a single quantum to be spread over this distance or, say, some 50 cm. at least.

Again, it was well known that the resolving power of a telescope depended upon its aperture. With a large object glass very sharp definition was attained at F (Fig. 2), whilst if the aperture were reduced by obscuring the margin of the lens, the sharpness disappeared and the light spread over a space such as that indicated between p and q, forming quite a patch. If the full beam were again admitted we got no light over the patch, the previous illumination having been destroyed by interference with rays coming from the margin of the lens; leaving merely a bright point at the centre. This was why astronomers liked great apertures such as the 100-in. reflector installed at Mt. Wilson, which gave very fine and well-defined images. Since each interference was due to one quantum, it would be seen that at Mt. Wilson a quantum ought to have a transverse dimension of 250 cm., and as already shown it should also be 50 cm. long. If further we took the fixed star measurements made with the Michelson interferometer, it would seem that the diameter of a quantum must be still further extended to 5 m. or 6 m. Hence interference phenomena appeared to indicate that the quantum could not be concentrated, but if it were not, no single electron could absorb its energy in the way it was actually proved to do.

It would be seen therefore, Professor Lorentz continued, that his conclusion was not very satisfactory. Though he had spoken all the evening about light he was compelled to leave matters in the dark. It might well be that in the near future, we should have the undulatory and corpuscular theories interwoven, and we might hope that they would be reconciled into a theory something like Newton's but embodying some very great differences. The light quanta were certainly not small balls of matter, but were merely packets of energy moving along, and they wholly disappeared when absorbed. Newton's corpuscles, on the other hand, would remain in existence after absorption.

SUMMER MEETING OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

IN choosing the North-Western and the Mersey and North Wales Centres for this year's summer meeting the Institution of Electrical Engineers has fixed on an area so rich in engineering interest that it will not be possible for us to attempt to deal in any way fully with more than a small proportion of the visits and other activities which are making up the meeting. The programme commenced at Manchester on Tuesday last on the morning of which day visits were paid to the works of Messrs. R. Johnson and Nephew, Limited, at Bradford, Manchester, Messrs. Mather and Platts, Park Works, Manchester, and the No. 2 Dunlop Rubber Cotton

Mills, Limited, at Rochdale. It was of course not possible to arrange that everyone taking part in the meeting should visit all the works, and members naturally chose those in which they felt the greatest interest. We were compelled to follow the same course, and shall make no attempt to deal with the Dunlop Cotton Mills, although it may incidentally be noted that these mills which have a motor installation of 14,000 h.p., are supplied from and must form a very useful load to the Ratcliffe Power Station of the Lancashire Electric Power Company. The power is actually obtained from the Rochdale Corporation, which purchases it in bulk from the power company. The Ratcliffe Power Station formed one of the visits in the afternoon, but there is no necessity that we should deal with it here as we described and illustrated it very fully in our issues of December 22 and 29 last.

Interest in the works of Messrs. Richard Johnson and Nephew centred chiefly in an electrically-driven continuous wire-rolling mill which was erected during the war, and which we are glad to say is in full operation at the present time. The installation is built in three sections, consisting of one roughing mill, with 11 sets of 12-in. rolls and two finishing mills, each consisting of seven sets of 12-in. rolls. The roughing mill is driven by a 2,750-h.p. motor which is designed to carry an overload of 100 per cent. for half a minute, and the finishing trains are driven by 750-h.p. motors of the same overload capabilities. The motors operate on a three-phase 6,600-volt supply taken from the Manchester Corporation high-tension mains through a sub-station in the works. The motors are controlled by push buttons which actuate oil-immersed solenoid-operated switches which are interconnected with the liquid starters in such a way that the switches can only be closed when the starters are in the open position. The starters are operated by small motors actuated from a relay connected with the potential transformer of the main high-tension circuit-breaker. The starters are also fitted with relays which control the starting current. A further refinement is the fitting of a solenoid-operated brake to the main mill motor in order to enable the mill to shut down quickly. This brake is operated automatically and will pull up the roughing train in 45 seconds.

The mill is fitted with a gas-fired continuous-bar furnace built on an incline. The bars are inserted, by means of a pair of punching rolls, at the top of the slope, and are pushed down sideways to the point of egress to the rolls by a series of hydraulic pushers which are actuated intermittently as required by the man who feeds the furnace with bars. Each bar pushes the next, and by the time a bar has arrived at the bottom of the furnace it is fully heated and ready to pass to the rolls. The feeding of the rolls is effected by a second operator who enters the bars in the rolls by means of a push bar, being assisted by a pair of pusher rolls. Two bars in parallel are dealt with by the mill, and water-cooling arrangements are fitted as the bar actually rises in temperature as it passes the various rolls. The formed wire passes to a lower stage in the building, and it emerges from the finishing rolls, and is reeled, and passes out of the shop by a series of continuous conveyors. The whole plant is arranged for continuous and rapid operation and the bars are carried to the feeding end of the furnace by an overhead crane fitted with a lifting magnet. The wire produced is mostly of No. 6 S.W.G.

The visit to Messrs. Mather and Platts' Newton Heath Works was of great interest, but such a large variety of manufacture is dealt with in the factory, and it is of such dimensions, that justice could only be done to it in a fully illustrated and detailed description. The works were commenced in 1900, when the well-known old Salford works had outgrown the possibilities of their sites. Many extensions to the new works have taken place since their inception and the main shops now consist of three bays 376 ft. long, ten bays 550 ft. long and four bays 600 ft. long, all under one roof. The shops are built without galleries and there are practically no partitions between bays, so that the whole arrangement makes a very striking shop, which should offer many conveniences for the moving of material and the exercise of overseership. As is well known, Messrs. Mather and Platt deal with a considerable range of manufacture, specialising particularly in electrical machinery, centrifugal and turbine pumps and textile machinery. In a sense, the electrical activities of the firm are of the greatest interest, since it is unusual, if not unique, for a large general engineering firm to deal in electrical manufacture to any considerable extent, and Messrs. Mather and Platt's activities in this particular direction must put them in a very favourable position for much industrial work as they will be able to quote for plants entirely of their own manufacture. Messrs. Mather and Platt can hardly be accused of cutting into any other firm's field in dealing in electrical manufacture, as they built the original Edison-Hopkinson dynamos and the first electric locomotives for the City and South London Railway.

The electrical manufactures by the firm are chiefly intended for the industrial field, and mainly consist of generators and motors which they build up to 3,000 kw. They, however, make rotary converters and have built machines up to 1,500 kw. A 1,200-kw. machine of this type which was on the test bed last Tuesday had brush gear of an attractive type and remarkably easy of access. A very large number of the firm's well-known turbo-pumps were also to be seen finished or in process of manufacture, including a number to act as boiler feed pumps for the new Salford generating station. A large amount of textile machinery of various kinds was also to be seen in the works, as well as various dye works plant and other chemical engineering machinery, which forms a branch of the firm's activities which we have not before mentioned. In connection with this class of work an example of the Plauson colloid mill was to be seen. We need not refer to this piece of apparatus more fully here as it is dealt with in detail in another part of this issue.

In dealing with some of the visits which were made in the Manchester district, before reporting any formal opening of the summer meeting, we are merely following the official programme, and it was not until mid-day on Tuesday that anything in the nature of a formal gathering took place. This function consisted of a lunch at the Midland Hotel given to the Institution by the Manchester Corporation Electricity and Tramway Committees. The Lord Mayor presided and welcomed the Institution to the city, a reply being made by Mr. Gill, the president. Immediately after this a departure was made for a further round of visits. They included the works of Messrs. Pilkington's Tile and Pottery Company, Limited, the works of Messrs. The Chloride Electrical Storage Company, Limited, and the Clifton Junction Power Station of the London, Midland and Scottish Railway Company, as well as the Ratcliffe Power Station, which we have already referred to, and to which we need not mention further. Time only allowed us to visit one of the other works—Messrs. Pilkington's—and this we may briefly deal with. The works are chiefly devoted to the manufacture of tiles, although the Royal Lancastrian pottery which is made at the works forms a singularly interesing if smaller branch of the firm's activities. The tiles are made up from a mixture of Cornish china clay, Devonshire ball clay, calcined flint—the raw material being obtained from the north coast of France—and a small amount of mineral matter containing felspar. The material is ground and mixed in mills and filtered through fine cloth before being cut to tile form. The tiles are actually made in hand-operated ball presses, which for the small tiles are worked by girls. The glaze, which is a glass coloured with metallic oxides, is put on to the tile by dipping it in a bath, the glass being held in suspension in the form of ground glass in water. For firing there are a large number of bee-hive ovens, as well as a continuous gas-fired tunnel oven. The Lancastrian pottery we have not space to deal with here beyond allowing ourselves to wonder why the pottery wheel is still operated from a hand wheel by a boy who, when we saw him, certainly did not attain any evenness of turning movement. We may also mention the lustre ware, for which Messrs. Pilkington claim to have re-discovered some of the secrets of the East. The lustre ware gives iridescence like a soap bubble, due to metallic coatings of a thinness approaching molecular dimensions. Oxides of silver or copper are applied to a piece of pottery which has already been fired. The piece is then treated in a reducing atmosphere over a wood fire, and the oxide is reduced so that a microscopically thin coating of silver or copper is left on the pottery. This thin coating gives the Newton's ring effect which is remarkably attractive and artistic.

The morning of Wednesday, the 6th inst., was spent in a visit to the new Barton Power Station of the Manchester Corporation. This was one of the most interesting visits of the whole meeting. This station has naturally attracted much attention, but no detailed or authoritative description of it has yet been published. Following on, as it does, the large Dalmarnock station of the Glasgow Corporation and the Nechells station of the Birmingham Corporation, the Barton station is naturally of very considerable interest as representing Manchester's contribution to the problem of modern large power-station design. A preliminary description of the station was given by Mr. S. L. Pearce, the city electrical engineer, in a paper read before the British Association in 1915, but an inspection of the actual building shows that the original proposals have been departed from in some important particulars. Mr. Pearce's paper will be found in our issue of September 24, 1915. The Barton station at present contains two 27,500 kw. turbo alternators and a third similar set under erection. These are of Metropolitan-Vickers make with Richardsons-Westgarth condensing plant. The third set will complete the station as now planned, and the fact that it is equipped with uniform plant of uniform size gives it an unusually fine appearance. There is no unfinished end wall to detract from the general effect, which is very fine.

The present station will have a plant capacity of some 75,000 kw., and to obtain further capacity the present idea is to build a similar station alongside giving about 150,000 kw. on the site. It is not certain, however, if this plan can be carried through owing to condensing water difficulties. The present plant obtains condensing water from the Manchester Ship Canal, and permission to utilise the water to the present extent was only obtained, we understand, with some difficulty. It is not certain if further abstraction will be allowed, and it may ultimately prove desirable to erect a further station on a new site. The water enters from the canal through three channels, each 7 ft. 2 in. wide, fitted with screening plant. These feed a circular culvert, 9 ft. 6 in. diameter, from which the water is drawn for the condensers by six Mather and Platt centrifugal pumps, each capable of delivering 20,000 gallons a minute against 37·5 ft. head. They are each driven by 320 b.h.p. motors. The pumps are situated in a basement 9 ft. 6 in. below the top water level of the Ship Canal, so that they are constantly flooded.

The boiler plant at the station is of considerable interest, the nine Babcock and Wilcox boilers each having an evaporation of 120,000 lb. per hour, being certainly among the largest, if not actually the largest in the country. The boilers are of the double-fired marine type, and are fitted with both economisers and air-heating arrangements. The working pressure and temperature are 350 lb. and 700 deg. C. Overhead bunkers are fitted capable of accommodating 36 hours' supply of coal. There is a double row of these bunkers, and independent chutes from each row feed each boiler, so that if desired it will be possible to carry coke in one set of bunkers and coal in the other, and feed a mixture to the furnaces. Coal weighers are not fitted in connection with the supply from these overhead bunkers, but a test-weighing arrangement is available to enable tests to be carried out on any boiler. The coal is, however, weighed as it passes from the store to the overhead bunkers. This arrangement is simple and straightforward, but does not allow of the coal consumption of each shift being logged.

The coal-handling arrangements are very complete. Four wagon tippers are situated across the canal from the station, and in connection with these tippers there is siding accommodation for 210 coal wagons. The wagons tip to bins from which two conveyors running under the main coal storage ground carry the coal to a gantry, where the conveyor becomes vertical and lifts the coal and either passes it over the canal by a further horizontal

conveyor or returns it in the same direction from which it has come, but overhead instead of underground. It is then tipped for storage on the land lying above the underground conveyor tunnels. The storage area communicates with the conveyors in the tunnels by a series of concrete chutes which cover a large part of the area so that the stored coal can be picked up and carried to the station merely by opening one or more of the chutes. The arrangement should be of great convenience in operation, and eliminates all handling by grabs. Coal may also be brought to the station by canal, and in that case is lifted by cranes carried on the conveyor gantries and led to the bin which feeds to the overhead bunkers or to the conveyor which puts the coal in store. The storage capacity of the main dump is 10,600 tons, and further tipping area is available bringing up the total storage to 22,500 tons. The coal-handling plant was supplied by Messrs. W. J. Jenkins and Co., Limited, of Retford.

The ash-handling plant of the station is very simple, but calls for much commendation, and we trust much imitation. The ash basement is at ground level, and standard gauge railway or road transport wagons can run below and be fed directly from the ash discharge hoppers and taken directly away for dump or other disposal. This very practical arrangement which is much less common than it should be does away with any necessity for suction ash plants, ash conveyors or similar expensive plant. We recollect commenting favourably on a similar arrangement at a very much smaller station, that at Messrs. Cammell Laird's Birkenhead shipyard. The electrical details of Barton we cannot deal with at the present time, beyond saying that the machines generate at 6,600 volts, and that they are tied solid to three-phase transformers which step up to 33,000 volts. Switching is done on the 33,000-volt side, the gear being supplied by the British Thomson-Houston Company. Barton in general gives the impression of a very fully-equipped station in which money has not been stinted if it was considered that the installation or elaboration of any item would be advantageous. We have not been able to obtain the actual cost per kilowatt at which the station has worked out, but understand it is in the neighbourhood of 22*l.* Mr. Pearce, in the paper to which we have referred, estimated the cost at 11*l.* per kilowatt, but this was, of course, a pre-war price, and much of Barton was equipped at the peak of costs. It may be remembered that the Dalmarnock station of the Glasgow Corporation was estimated to cost 10*l.* a kilowatt, but actually cost 20*l.*

After the visit to Barton the members of the Institution paid a visit to the Trafford Park works of the Metropolitan-Vickers Electrical Company, Limited, where they were entertained to lunch by the company. A speech of welcome was made by Sir Philip Nash, the chairman of the company, which was suitably replied to by the president. Any account of the very many and remarkable activities of the Metropolitan-Vickers Company we must defer until next week.

(*To be continued.*)

LITERATURE.

Alfred Yarrow: His Life and Work. By ELEANOR C. BARNES (Lady Yarrow). London: Edward Arnold and Co. [Price 10*s.* 6*d.* net.]

THOSE who have the privilege of a personal acquaintance with Sir Alfred Yarrow will have no difficulty in understanding he was very strongly averse to, and forbade the publication of, any account of his life and work until a time which it is hoped is far distant. They will also agree that in this one matter his judgment, usually so sound, was in error, and that Lord Knutsford, who persuaded him to give his reluctant consent, deserves the thanks of his many friends and all those who we are sure will read this worthy record with the greatest interest. For the book is not only the history of a leading engineer and captain of industry, but is also to a large extent the history of marine engineering during the last fifty years, and more especially that portion of it in which Sir Alfred has been most intimately and successfully concerned, viz., the development of high-speed vessels. But more than this, it is a book which all young engineers should read, since it is a remarkable example of one who, as Lord Knutsford points out in his foreword, started out with the proverbial half-crown or less, but being endowed with good health, strong character, indomitable energy and perseverance, has achieved a success which has made his name and that of his firm famous throughout the world. Further than this, many engineering problems, with their successful solutions, are fully and very clearly explained.

Sir Alfred Yarrow was born in London in January, 1842, the son of Mr. Edgar Yarrow, a clerk in the employment of a firm of West India merchants, who fell in love and subsequently married the daughter of the head of the firm. The son inherited the business ability of his mother, to whom he was devotedly attached. Starting at a private school at the age of six, his old schoolmaster describes him as learning as if by magic the subjects in which he took a liking, excelling in mathematics, physics and geography, and having a talent for engineering. At the age of eight his inventive faculty was awakened and, bored by the monotony of holding a skein of wool whilst an aunt wound it, he devised an automatic wool-winder. At the age of thirteen University College School was selected for his further education, and there he had Joseph Chamberlain as a schoolfellow.

At the age of 15½ years Yarrow was apprenticed to Messrs. Ravenhill, marine engineers, who had built many of the engines for the early steam vessels of the British Navy. As evidence of the thoroughness which is an outstanding feature of his character, the young apprentice spent his Saturday afternoons working with a jobbing smith, the apprentices at Ravenhill's not being allowed in the smith's shop at the works. Professor Faraday's lectures were attended in the evenings, and from the knowledge acquired thereby, Yarrow and his friend Hilditch made and erected a telegraphic communication at a cost of half a crown between their two homes, the first private wire used in London. At the age of eighteen Yarrow with his friend initiated the "Civil and Mechanical Engineers' Society," an association which some years later became incorporated with the Society of Engineers.

On completing his apprenticeship in 1863, Yarrow was offered a post as draughtsman at Ravenhills at a salary of £100. The offer was accompanied by some slighting remarks on the poor financial position of his father which the young engineer resented, and he refused the offer.

Three years before this Yarrow and Hilditch visited the Royal Agricultural Society's Show, and inspecting some steam ploughs which were exhibited, they set to work to design a plough which would obviate some of the difficulties experienced when using the machines which were at the time available. The design was patented, and in 1861 was fully described by the two inventors in a lecture to the Civil and Mechanical Engineers' Society. Messrs. Coleman, of Chelmsford, purchased the rights in the patent, opened an office in London for the transaction of business in connection with it, and placed young Yarrow in charge at a salary of £100. He had sufficient leisure to undertake drawing work, inspections and other odd engineering services by which his salary was appreciably increased. He continued in the office two years, and so impressed his employers with his strong personality that they offered him a partnership in the firm and management of the works. Fortunately for Yarrow the offer fell through, although at the time he was very disappointed.

For some time previous the young engineer had been considering the starting of a works of his own, and was on the look out for a suitable partner with a little capital. From royalties on his patents and money earned in his spare time, Yarrow had accumulated a capital of £1,000, and with this he entered into a partnership with a man named Hedley. The latter had no capital to bring into the business, but instead claimed that the influence which he had with the river steamboat owners would bring enough work to keep the firm fully employed. A small yard with workshops was taken on the Folly Wall in the Isle of Dogs, and preparations made for the expected business. Work, however, was very slack, and the balance sheet for the first year showed a loss of £100, which at the end of the second year had increased to £2,000.

Yarrow, whilst an apprentice at Ravenhills, had with his friend Hilditch designed and built a small steamboat, and, faced with the necessity of developing in a new direction to save his business from ruin, he advertised that the firm was ready to undertake the building of steam launches. Within three days a Colonel Hamplin had ordered a 24-ft. steamboat to Yarrow's design, the contract price being £145. The actual cost of building was £200, but the young engineer was so satisfied with the results of the trials that he almost forgot the loss involved on the contract. Fortunately, at the end of the summer, he bought the boat back for £100 and sold it the same day for £200. The following summer he again bought the vessel for £100 and re-sold for £300 to a Russian gentleman, by whom the boat was taken to Petrograd.

Appreciating the result of his first advertisement, Yarrow presented a framed photograph of the steamboat to every inn on the Thames, with the result that he was given numerous orders for similar boats. The tide of fortune had then turned, and from that time onwards Yarrow knew only success. Between the years 1868 and 1875, 350 steam launches were built by the firm, and in the latter year the partnership between Yarrow and Hedley was dissolved, the latter drawing a large sum out of the firm's capital on condition he should not open a competitive business. The condition was not faithfully observed; some trouble was caused, but Yarrow successfully overcame it.

It was just before this that Yarrow designed and built the first of many successful vessels of a new type. The Nyassa Mission, formed as a memorial to Livingstone, sent two representatives to the firm to explain the qualities of a vessel required for service on Lake Nyassa. Yarrow was absent, and they saw his partner Hedley, who told them the vessel was impracticable. Luckily they met the more energetic partner as they were leaving the premises, and he informed them he would undertake the work. The vessel and her machinery were built in small pieces, no part weighing more than 50 lbs., to allow of native transport for 60 miles before erection. The vessel was of shallow draught, proved a great success, and, although necessarily of very light construction, remained in service over 33 years. Three vessels of the same type were built shortly afterwards for the British Admiralty and were followed by many others for mission, commercial and war purposes, amongst these being a number for service in Iraq during the war. Successive vessels have each been fitted with improvements suggested by the firm's experience.

Spar torpedoes were used in the American Civil War, and in 1873 a Confederate officer engaged by the Argentine Government to organise a torpedo defence came to England, and placed an order with Yarrow for a steam launch to carry a spar torpedo. This was the first vessel for torpedo purposes built by the firm. She was 55 ft. in length and of the standard launch type, and was followed by one 75 ft. long for the Dutch Navy. In 1877 Whitehead had sufficiently developed his motive torpedo to bring it to the notice of various Governments, who immediately saw its great use for war purposes. Yarrow was soon very busily engaged in designing and building torpedo-boats to carry such torpedoes for practically all the maritime nations. In addition to the hulls and machinery, the torpedo tubes were designed and constructed by the firm.

One such boat was built for the British Admiralty as an experiment. The specified speed was 18 knots, and there were substantial penalties for failure to obtain this speed. The Yarrow-built boat attained 21·9 knots on her trials, nearly three knots in excess of the highest speed of vessels built by other firms. Before she was reported ready for her official trials 25 different propellers were designed and tried by the builders, a striking example of the thoroughness with which all difficult problems are solved by the firm. This success was followed by an order from the Russian Government for a design of a torpedo-boat to be built in that country and of which 100 were subsequently constructed.

At the same time the Russian public subscribed money to build two larger torpedo-boats for their

Navy, and the order for these was placed with Yarrow. On completion the political situation was such that the British authorities refused permission for them to leave and offered to purchase them. The price Yarrow proposed for their sale was that which he had charged the Russians, but this the Admiralty considered excessive. Thereupon Yarrow suggested the same price as Messrs. Thornycroft were being paid for similar vessels. This was agreed to, subject to heavy penalties for failure to obtain a speed of 18 knots, and, at Yarrow's request, a premium for speeds above. On trial the vessels attained speeds of 20·8 and 20·6 knots, which resulted in a price of nearly £2,000 more being paid than that first asked for by Yarrow. These two boats took part in the Naval Review of 1878, and their performances and behaviour, widely reported in the public press, brought Yarrow's name into great prominence. The Admiralty were severely criticised in the House of Commons for purchasing the vessels, as it was stated they were of too light construction for sea service. Yarrow was ordered to steam them from the Thames to Portsmouth, and in view of the doubts publicly expressed as to their strength in a seaway and to encourage his men, Yarrow and his wife made the trip around in them. They proved excellent sea boats, but on presenting the bill for the firm's expenses the Admiralty deducted those involved by Mrs. Yarrow, as they considered her presence unnecessary for successful navigation. Some difficulty in developing power in the torpedo-boats built in Russia to the Yarrow design led to his introduction of the closed stokehold system of air supply, which successfully overcame the trouble, and long remained a prominent feature of subsequent similar craft.

In 1880 a still larger torpedo-boat was built by Yarrow for the Russians, and many other nations followed with orders for similar vessels, including 24 for the British Admiralty. One of these, No. 79, was the first fitted with triple expansion engines, her speed on trial being 2¾ knots in excess of that of her sister vessels. She was subsequently commanded by the King, then Prince George.

In 1892, Yarrow called on Sir John Fisher, then Controller of the Navy, and informed him that the French were building some exceptionally fast torpedo boats which were superior to the British vessels. He was requested to forward a full report, and also a design of a vessel which would surpass the French type. The result was an order for the Havock and Hornet which attained speeds on trial of 26·1 knots and 27·3 knots. The Havock was fitted with locomotive, and the Hornet with Yarrow watertube, boilers, this being the introduction of the latter type into the British Navy. The fitting of the Yarrow boiler was also accompanied by a decrease in weight, the Hornet being 11 tons lighter than the Havock. The Yarrow boiler had been in development for some time, for it was in 1877 the idea first occurred to the head of the firm, and the following incident is related in the book under notice:—Yarrow was at lunch, when Crush, the head of the boiler department, looked in. Said Yarrow, "Crush, we must wake up about watertube boilers." Crush agreed. "Why not a boiler like this," said his chief, putting his hands together with the fingers sloping on each side. "All right," replied Crush. "Straight tubes," said Yarrow. "We will go ahead and make one," replied his assistant. And such was the genesis of the Yarrow boiler, but it was not until after many experiments to determine the best slope and size of tubes, dimensions and shape of the steam and bottom drums and all other particulars necessary to obtain the best results that the boiler was proposed for installation on service. Thousands of pounds were spent on these experiments, but the result has been justified, for the Yarrow boiler is now in use in all the navies of the world. The success of the Havock and Hornet, the first of the destroyer type, was followed by a very large programme of similar vessels for the British Admiralty. A further stage in destroyer development was reached when Yarrow built the Sokol for the Russians. In this vessel steel of a higher strength than the mild quality hitherto employed was used for the main structure, with a consequent saving in weight and size of vessel. This feature has been introduced in all subsequent destroyers in all navies. The Sokol was followed by an order from the Japanese Government for eight destroyers and 12 torpedo boats in which a further increase in size and improvements were introduced. The steam turbine for the propulsion of torpedo craft was not directly due to Yarrow, but it is needless to say he appreciated its advantage for such purposes and was not tardy in introducing it into his designs. Before leaving the subject of high speed torpedo craft the generous tribute paid by the authoress of the volume we are reviewing to Messrs. Thornycroft and Messrs. Normand — Yarrow's most prominent competitors—must be mentioned.

Another notable development in marine engineering, with which the name of Yarrow will always be associated, is the balancing of marine engines for the purpose of minimising vibration. Crossing the Atlantic in 1890 in the Majestic, Yarrow noticed the vibration in his cabin was appreciably greater than that in the cabin of a friend a short distance away. A rough apparatus for measuring vibration was devised and with it Yarrow measured the extent and period at various positions on the ship, and from the results so obtained traced the cause to the unbalanced weights of the reciprocating portions of the propelling engines. Previously it had been attributed to the action of the propellers. Returning to England extensive experiments were instituted by Yarrow for the purpose of arriving at a remedy to the defect which with quick running engines in light craft caused considerable discomfort to the crew. As a result of these experiments and investigations, a design of a four-cylinder engine having the weights of the reciprocating parts proportioned to eliminate all vibration, was prepared and patented in conjunction with Dr. Schlick of Hamburg. The vibration problem was thus solved and in a manner typical of the head of the famous firm, viz., by the most thorough experimental investigation.

The little firm which had been started by Yarrow and Hedley in the Isle of Dogs in 1866 had experienced remarkable success and had, by the period with which we are now dealing, outgrown its available space. Partly from this, and also on account of the high local rates and the general unsuitability of London for shipbuilding, it was decided to shift the works to Scotstoun, Glasgow, in 1906. It was again typical of Yarrow, that every step in the transfer was so arranged as to inconvenience his employees to the minimum possible extent. Many notable craft have been built at the Glasgow works, and although at the present time work is not as plentiful as it might be, all will hope this period will soon pass away, and the firm will pass on to more successes.

One other point must be mentioned before leaving Sir Alfred's work in the domain of engineering, and this is in connection with the great engineering strike of 1897. This originated in a demand made by the Amalgamated Society of Engineers on the London employers for a reduction of hours from nine to eight. The letter received by the employers was in very peremptory tones, and at a large meeting of master engineers the tone of the letter was remarked on and it was proposed to refuse the demand and reply in the same spirit. Yarrow opposed the proposal, suggested that such a course would alienate public sympathy, and that a courteous letter should be sent acknowledging receipt of the men's letter, promising consideration, and a fuller reply later. He also suggested that employers in the North, where work was plentiful, should be consulted, with a view to concerted national action. This was done, and as a result the Employers' Federation was formed.

So far as Yarrow's own works was concerned his action was prompt and effective. He was worried by the action of his workmen, with whom he had always been on excellent relations. He advertised for non-union fitters, purchased the R.M.S. Southampton, berthed her off his works, and fitted her as a floating hotel for the workmen. The latter joined up in numbers sufficient to allow of the works being carried on during the six months' strike.

Sir Alfred Yarrow had retired from active participation in his business just before the war. On the declaration of war he returned, placed his works at the disposal of the Admiralty, and stood ready to do anything which was required of him. He was soon busily engaged, for no less than 29 destroyers were completed during the war, and also a number of shallow draught gunboats which did excellent service on the Tigris. In addition submarines and other craft were built. But besides this substantial contribution to the naval forces, Sir Alfred devoted considerable time and money to other useful war work. A cure for frost bite, an invisible veil for soldiers, a lifesaving waistcoat, artificial limbs, smoke screens and submarine detection occupied his attention and that of his assistants. Propaganda in the press of neutral countries was also instituted by him, and did good service for the Allies.

In the foregoing remarks only Sir Alfred Yarrow's great work in the domain of marine engineering has been referred to. There are many other aspects of his life and work related in the book under notice which will be read with interest by the general reader. His devotion to his mother, his relations with his friends and workmen, his great gifts to charity and to scientific research, including the Froude Tank and his latest gift to the Royal Society, his views on the distribution of wealth, and on the education of women, all show him to be a remarkably broad-minded, liberal and lovable man.

Lady Yarrow deserves our best thanks for the book which she has written so well, and especially for those descriptive engineering portions which could not have been improved by a highly trained engineer. The book is illustrated by many photographs and coloured plates which taken apart from the letterpress, indicate clearly the evolution of the various types of vessels which Sir Alfred has designed and perfected.

BOOKS RECEIVED.

Design of Machine Elements. By J. A. MEASE, M.E., and GEO. F. NORDENHOLT, M.E. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

Handbook of Steel Erection. By M. C. BLAND. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

Practical Factory Administration. By MATTHEW POROSKY. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

Steam Turbine Principles and Practice. TERRELL CROFT, Editor. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 15*s.* net.]

Transactions of the American Society of Civil Engineers. Vol. LXXXV, 1922. Edited by the Secretary. New York: Offices of the Society.

United States Bureau of Mines. Technical Paper No. 301. *Proposed Method for Reducing Mineral Waste in the Wisconsin Zinc District, Wisconsin.* By W. H. COGHILL and C. O. ANDERSON. [Price 10 cents.] No. 323. *Specifications for Petroleum Products and Methods for Testing.* [Price 10 cents.] No. 327. *Accidents at Metallurgical Works in the United States during the Calendar Year* 1921. By WM. W. ADAMS. [Price 5 cents.] Washington: Government Printing Office.

Sous-Marins, Torpilles et Mines. By M. LAUBEUF and HENRI STROH. Paris: J. B. Baillière et fils. [Price 60 francs.]

United States Geological Survey. Bulletin No. 727. *Potash in the Greensands of New Jersey.* By G. R. MANSFIELD. [Price 50 cents.] Professional Paper No. 122. *Copper Deposits of the Tyrone District, New Mexico.* By SYDNEY PAIGE. [Price 25 cents.] Water Supply Paper No. 497. *Surface Water Supply of the United States,* 1918. Part IX. *Colorado River Basin* [Price 15 cents.] Washington: Government Printing Office.

THE INSTITUTION OF CIVIL ENGINEERS.—The annual conversazione of the Institution of Civil Engineers has been fixed to take place on Thursday, July 12, at the Institution, at 8 p.m.

ENGINEER TRAINING IN THE NAVY.—The Admiralty has announced that the next preliminary examination of engineering for officers specialising in this subject will be held on Wednesday, July 25, and will consist of an oral examination to be arranged for locally and a written paper which will be set and examined by the Admiralty. It may be mentioned that there are now two schemes of engineering training in operation, and under the new scheme inaugurated last year officers volunteer immediately on completing their training as cadets and pass into the Royal Naval College at Keyham as midshipmen, undergoing there a course of training which extends over a period of three years and eight months. The examination above referred to is for officers volunteering under the old scheme, and these officers have a six months' preliminary course at Greenwich and a twelve months' course at Keyham. We also learn that in future acting mates (E) will receive the whole of their training at Greenwich, whereas hitherto these officers have received a six months' course of instruction at Keyham. The change is due to the increased demand for accommodation at Keyham arising out of the new training scheme above referred to.

ALTERNATING-CURRENT RECTIFIER FOR ACCUMULATOR CHARGING.

CONSTRUCTED BY THE CRYPTO ELECTRICAL COMPANY, LIMITED, ENGINEERS, WILLESDEN, LONDON.

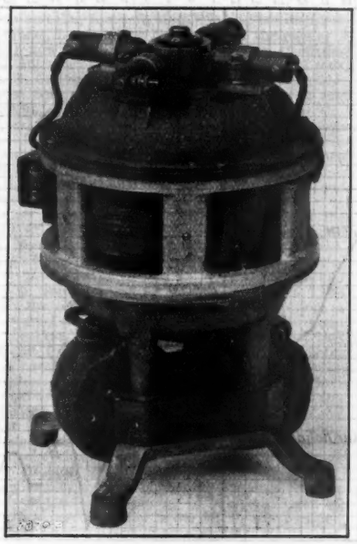
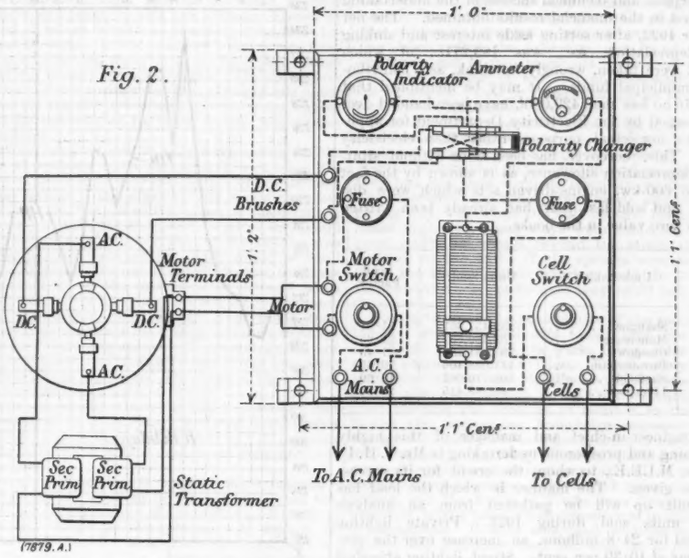


FIG. 1.

Fig. 2.



THE recent development of broadcasting in most of the thickly populated areas of the country has caused a remarkable increase in the number of small accumulators in use, since these are necessary for heating the filaments of the valves employed in wireless-receiving sets. Consequently a considerable demand has arisen for apparatus to enable such accumulators to be charged by the user from the domestic electric lighting or heating installation. When the current supplied is continuous, the process of charging is simple enough, although it may be comparatively costly if the greater part of the energy taken from the mains is absorbed in resistances, but in the large and increasing number of areas in which alternating current is now supplied some form of rectifier must be installed before a unidirectional current suitable for accumulator charging can be obtained.

Many different types of rectifiers are available for the purpose, and of these we may mention the Nodon valve, vibrating-reed, thermionic valve, and mercury vapour rectifiers, as well as the more elaborate motor generators and rotary converters. The rectifier which we illustrate in the accompanying engravings, however, has recently been put upon the market by the Crypto Electrical Company, Limited, Acton-lane, Willesden, N.W. 10, and this employs a synchronous motor to drive a commutator arranged so as to reverse the connections from the secondary winding of a transformer at each half cycle of the supply frequency, and in this way a pulsating, but unidirectional, current, quite suitable for accumulator charging, is obtained. Fig. 1 shows the appearance of the rectifier, while Fig. 2 is a diagram of connections for the machine and the switchboard, which is usually supplied with it. The machine illustrated will supply 5 amperes of rectified current at either 10 volts or 15 volts, but larger sizes are made, the next largest giving 10 amperes at 15 volts. Rectifiers on the same principle, we may mention, are made for supplying kinematograph arcs, the output of such machines being either 50 amperes or 80 amperes at about 70 volts.

As will be seen from Fig. 1, the small machine to which we are now referring, consists of a vertical spindle motor mounted above a static transformer and having the rectifying commutator at the upper end of the spindle. Four fixed radial brushes set at 90 deg. bear on the commutator, two of these being connected to the secondary winding of the transformer, as shown on the left of Fig. 2, while the other two supply the rectified current. The motor, it should here be explained, is a four-pole machine, so that on a 50-cycle circuit it runs at 1,500 r.p.m. The commutator thus makes one revolution during two complete cycles of the alternating current, and as the commutator is composed of two main segments with insulated segments between them, it will be clear that one of the direct-current brushes will be connected to one of the alternating-current brushes for one-quarter of a revolution and to the other alternating-current brush for the next quarter of a revolution. The change in connection from one brush to the other takes place just as the alternating current changes sign, so that the polarity of the direct-current brush remains constant while the machine is running. There is, however, nothing to control the actual polarity of the direct-current brushes when the machine is started up, so that either brush may be positive or negative, and, for this reason, a small moving-coil polarity indicator is fitted on the switchboard. The position of the pointer of this instrument shows at a glance which way the direct current is flowing, and if this is incorrect for the polarity of the battery being charged it can at once be corrected by means of the double-pole double-throw switch mounted on the board, as shown in Fig. 2; there is, of course, no possibility of the direction of the current changing while the machine is running. An ammeter, rheostat, cut-out and switch are provided in the direct-current circuit, as shown in Fig. 2, which also shows the switch and cut-out fitted in the alternating-current circuit.

To start up the motor it is only necessary to close the main switch, since a split-phase winding is provided on the stator, and the rotor is of the squirrel-cage type. The motor thus behaves as an induction motor in starting, since the split-phase winding produces a rotating field, but a centrifugal switch on the spindle automatically cuts out the inductive winding when the machine has run up to about 75 per cent. of full speed, after which the rotor rapidly pulls itself into synchronism with the stator field which is then pulsating and not rotating. For synchronous running it is, of course, necessary to have four salient poles on the rotor, and these are produced by simply cutting four large longitudinal slots in the rotor laminations, so that the latter become of cruciform shape. The rotor bars are left in position in the parts from which the laminations have been removed, so as to give the continuous squirrel-cage winding necessary for starting up, but the whole of the bars, and the short-circuiting rings which support them at the ends, are of exceptionally heavy construction to give the necessary rigidity to the bars situated in the gaps between the poles. This construction, which was patented in 1915, in addition to the self-starting feature, has the advantage that no slip rings are needed to supply current to the rotor such as are necessary in a salient pole rotor of ordinary design.

The lower end of the rotor spindle runs in a ball-thrust bearing and the upper end in a plain bushed bearing. The whole machine, in fact, is designed, both mechanically and electrically, so as to be suitable for the comparatively long continuous runs necessary for accumulator charging. The commutator, we may add, although arranged electrically as shown in the diagram, Fig. 2, is actually constructed on lines exactly similar to those of an ordinary direct-current commutator having equal segments over the whole periphery, except that the mica insulation between the segments is replaced by copper packing pieces where necessary in order to form the long electrically-continuous segments. This construction, we understand, has been found to maintain its cylindrical form under working conditions better than a commutator composed of alternate long and short segments. Another point in the design which should be mentioned is that the transformer is provided with separate primary and secondary windings, so that there is no possibility of obtaining shocks from the low-tension side as may happen with auto-transformers.

With regard to the efficiency of the rectifier we may point out that except for the energy required to drive the motor at what is practically no load, the only losses are those occurring in the static transformer, but for the small outputs required the former naturally constitute a rather large proportion of the whole. The makers inform us, however, that the overall efficiency ranges from 40 per cent. to 50 per cent., according to the frequency of the supply, and either figure, we may remark, is considerably higher than would be obtained from a motor-generator set having the same output; the actual energy consumption is given as about 1 unit in 5 hours. The degree of rectification is also high, the root-mean square value of the rectified current being only about 22 per cent. higher than the arithmetic mean value, whereas the theoretical difference for a pure sine wave would be 11 per cent. These considerations, added to the fact that the machine is sold at a reasonably low price, should lead to its extensive adoption.

ELECTRICAL DEVELOPMENT IN SHANGHAI.

THE report of the Electricity Department of the Shanghai Municipal Council for the year ending December 31 last is now to hand, and as usual it is of a nature to deserve the admiration and to excite the envy of power-station engineers in this country. The sales of electricity amounted to no less than 232,457,361 kw.-hours, an increase of 25·4 per cent. on the previous year, and the load-factor remains at the same exceptionally high figure as last year, namely 51·5 per cent. The whole of the power is generated by steam. The significance of the above figures is emphasised by comparing them with those of the five largest municipal undertakings in Great Britain, most of which serve densely populated and highly industrial areas. The table on the next page gives the comparison.

Of the total units generated at Shanghai, 6·86 per cent. were used for auxiliary purposes. In 1921, 8·44 per cent. of the gross production was used in this way, and in 1920, the figure was 8·05 per cent., so that a substantial improvement in station power efficiency has been brought about. The Municipality of Shanghai has two stations, the large one at Riverside with a plant capacity of 121,000 kw., and an old one at Fearon-road

which contributes less than 1 per cent. of the total output, and would have already been shut down but for its convenience in connection with the traction supply. A new "superstation" is being erected at Fearon-road, the building being now practically completed and much of the E.H.T. switch gear erected. The enterprise and technical success of the undertaking is reflected in the financial results obtained. The net profit for 1922, after setting aside interest and sinking fund, depreciation, &c., was 183,271*l.*, of which 103,500*l.* were taken, wrongly we think, as a contribution to municipal funds. It may be mentioned that since 1916 no less than 429,000*l.* have been handed over to the council by the Electricity Department for application to municipal purposes other than electricity supply. This, moreover, has been done without stinting the depreciation allowance, as is shown by the fact that two 600-kw. engine-driven sets which were dismantled and sold last year, had already been written down to zero value in the books.

Year Ending	Undertaking.	Units Sold.	Load Factor.
1922	Shanghai	232,457,361	51·51
1922	Manchester ..	158,489,732	21·65
1922	Glasgow	131,341,783	21·45
1922	Birmingham ..	111,038,406	20·65
1922	Sheffield	103,170,062	18·69
1921	Liverpool	88,188,415	24·96

The engineer-in-chief and manager of this highly enterprising and prosperous undertaking is Mr. T. H. U. Aldridge, M.I.E.E., to whom the credit for its success must be given. The manner in which the load has been built up will be gathered from an analysis of the units sold during 1922. Private lighting accounted for 24·8 millions, an increase over the previous year of 10·39 per cent. Street lighting absorbed 1·8 millions, an increase of 7·82 per cent. Heating and cooking took 1·7 millions, an increase of 27·48 per cent. Power increased by 28·18 per cent. to 198·5 million units, and current for traction increased by 12·29 per cent. to 5·6 million units. The estimated net profit for 1923 is 209,842*l.*, and judging by Mr. Aldridge's previous records there is little doubt that it will be earned.

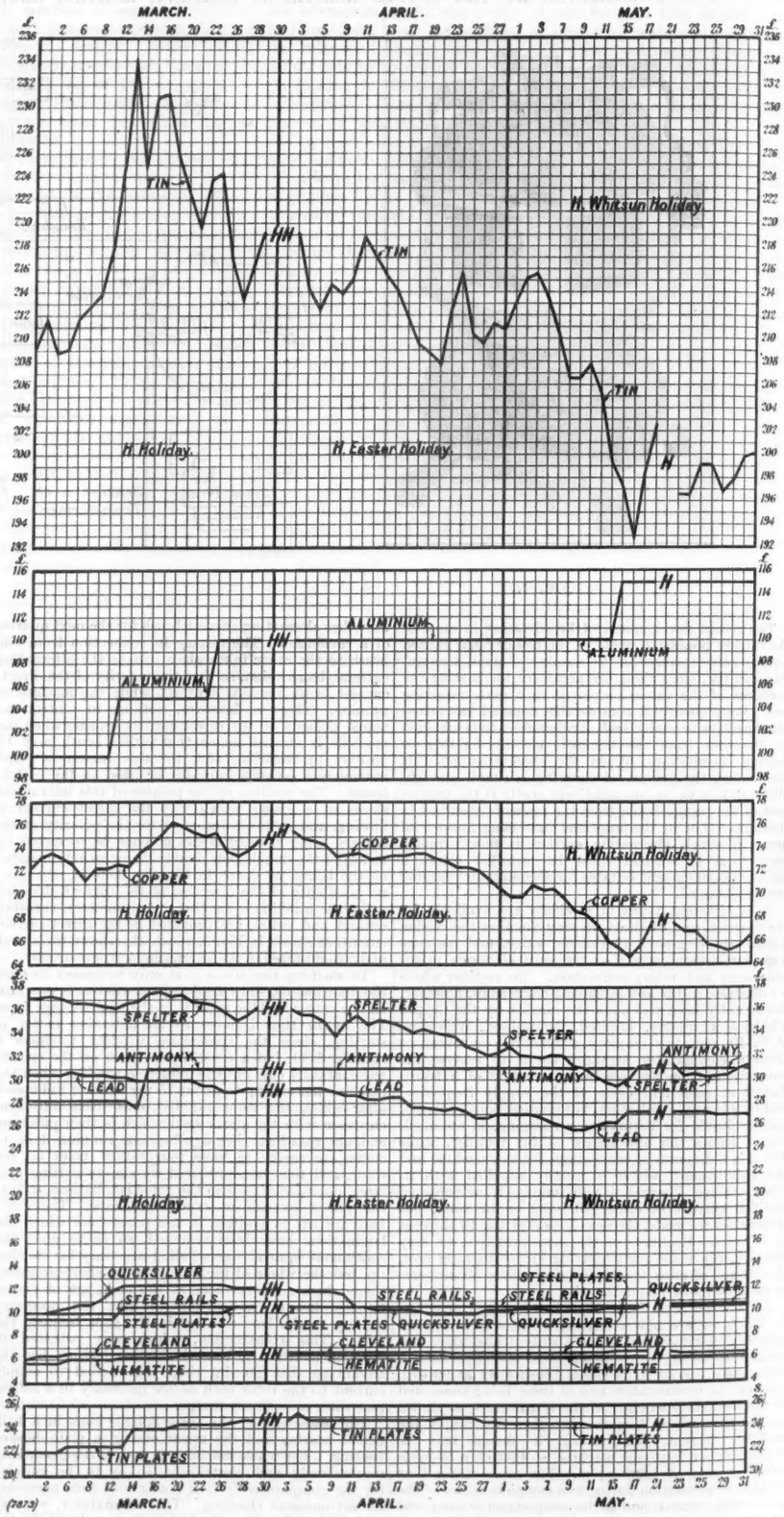
METAL PRICE DIAGRAMS.

NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

TRIALS OF THE BRISTOL "CHERUB" AERO ENGINE.—We understand that the small Bristol "Cherub" aero engine, which has been designed for use on light aircraft, has recently completed the Air Ministry type test under the supervision of the Aeronautical Inspection Department, with very satisfactory results. The engine, which is of the flat twin type and has a cylinder capacity of 1,086 cub. cm., was subjected to a 50 hours' endurance test and ran for the whole period without a stop at 90 per cent. full load. The average power developed was 15·4 h.p. at 2,200 r.p.m., and the average fuel consumption was 9·7 pints of petrol per hour; the oil consumption was 0·63 pint per hour. The power developed was absorbed by a Froude dynamometer, and a fan, coupled directly to the engine crankshaft, was used for cooling purposes. On the completion of the endurance test, and without any adjustment, the engine was run over a range of powers and speeds from 15 h.p. at 1,775 r.p.m. to 19·68 h.p. at 2,360 r.p.m., in order to obtain data for the construction of a power curve, and after this had been done a further run for 1 hour at full throttle was made, the engine developing 18·5 h.p. at 2,200 r.p.m. Finally the engine was stripped and measured and found to be in perfect condition. We understand that this is the first engine suitable for light aircraft to be subjected to an official test.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



ASSOCIATION OF CONSULTING ENGINEERS (INCORPORATED).—The ninth annual general meeting of this association was held at the Caxton Hall, Westminster, on May 28, when the report of the committee for the twelve months ending on April 30 was adopted. Interesting remarks were made concerning the help afforded to the members by the association in obtaining the integral payment of agreed fees for consulting engineering work.

INVESTIGATION OF THE EXPLOSION OF A STILL.

A FORMAL investigation has been made by the Board of Trade, under the provisions of the Boiler Explosions Acts, 1882 and 1890, with regard to the cause and circumstances attending the explosion of a boiler, which occurred on July 31, 1922, at the Holmes-street works of Messrs. Brotherton and Co., Limited, ammonia and tar distillers, City Chambers, Leeds. The investigation, the results of which have now been published, was held on December 13, 14, 15, 16, 19 and 20, 1922, at the Town Hall, Leeds, when Mr. G. C. Vaux appeared for the Board of Trade; Mr. Charles Scriven, of Messrs. Peckover, Scriven and Co., solicitors, Leeds, for Messrs. Brotherton and Co., Limited, and Mr. Herbert Henry Blackburn, their works manager. The Commissioners were Messrs. A. A. Hudson and H. P. Vining. By the explosion, two men were so severely injured that they died within an hour of the explosion. Two other men were injured, and suffered from shock, but subsequently recovered.

The boiler, referred to as a still, formed part of the plant used at the works in the production of liquid ammonia from liquor obtained from the gas works. It was a cast-iron vessel, 7 ft. 6 in. internal diameter by 15 ft. 3 in. overall in height, with a flat bottom and a dished top, and it was built up of 21 sections. The walls, with the exception of the cylindrical portion of the cover, were $\frac{7}{8}$ in. The cover was 1 in. thick throughout, and the base $1\frac{1}{4}$ in. thick in its thinnest part and $1\frac{7}{8}$ in. in its thickest part. Twelve $1\frac{1}{4}$ in. diameter iron stays, passing through lugs on the cover and the bottom portion respectively, tied the sections together, and tightness at the joints was secured by means of the jointing material fitted into an annular groove, $\frac{1}{4}$ in. by $\frac{3}{8}$ in., in the face of the underneath ring, the rings being slightly flanged for that purpose. At the upper end of the stays steel springs of $\frac{1}{4}$ in. diameter wire were fitted in order to provide for the free expansion of the still. Each of the smaller sections of the still was formed with a base or tray 1 in. thick, having openings arranged so that while they permitted the liquor which was pumped in at the top to descend to the bottom, they maintained the liquor at a certain depth on the tray at all times, whilst other openings, provided with bonnets, the undersides of which were perforated and were at a level below that of the liquor on the tray, allowed the heated gases to rise, the bonnets causing them to mix intimately with the liquor at each stage. An arrangement of steel pipes of 2 in. diameter, perforated, and with open ends nozzled down to $\frac{3}{4}$-in. bore, was fitted in the bottom of the still below the level of the liquor contained therein, and was supplied from a steam main working at 50 lb. pressure per square inch.

At the time of the explosion the still was supplied with the following fittings: One 2-in. bore inlet pipe in the cover for cool liquor; one $2\frac{1}{2}$-in. bore inlet pipe between the fourth and fifth trays from the top for hot liquor; one 3-in. bore liquor outlet pipe near the base with a gate valve situate about 3 ft. from the pipe connection to the still; one 3-in. diameter steam inlet valve fitted at a distance of about 2 ft. from the bottom section supplying a 2-in. bore pipe; one open-type lever safety valve of 2 in. diameter loaded to blow-off at about 17 lb. pressure per square inch, with a 2-in. plug cock interposed between it and the tee-piece to which it was connected; one 2-in. cock and pipe fitted to a tee-piece on the cover for waste gases; one thermometer pocket in the cover; one gauge glass fitted to the bottom section $19\frac{1}{2}$ in. centres; three pressure gauges, viz., two in the bottom section and one in the cover, graduated to 20 lb. per square inch.

The still was made by Messrs. Ashmore, Benson, Pease and Co., Limited, gas and constructional engineers, Stockton-on-Tees, and its age at the time of the explosion was $18\frac{1}{2}$ years. The vessel was not insured, and no one with any engineering skill had inspected it.

In their report to the Board of Trade, the Commissioners state that the vessel which exploded was not a boiler in which steam was generated, but a vessel in the nature of a still, into which steam was admitted under pressure, and thus became a boiler within the terms of the Boiler Explosions Acts.

The vessel was erected at Messrs. Brotherton's Holmes-street works in 1904, and in January of that year, correspondence took place between the owners and the makers, as to the safe working pressure of the still, and the owners inquired whether in the event of the pressure in the still reaching 20 lb., there would be any risk. The makers replied that they could not recommend a greater pressure than 5 lb., and, in a later letter said that they did not think Messrs. Brotherton need fear 10 lb., the pressure that they had said they might at times work at. This was in reply to a letter from Messrs. Brotherton, in which they said it was not their intention to work at anything over 6 lb. to 8 lb., but the pressure might get up to 10 lb. or over. The joints of the various sections were made with a groove into which, as originally supplied, rubber was inserted, projecting $\frac{1}{4}$ in., so as to squeeze tight under pressure.

It was intended by the makers that by this method of jointing when the still was heated, as it would be by the admission of steam, the bolts or stays before referred to would hold the sections tight, one on the other, but that when the upper part of the still was cool there would be a space between the metal and the joints which would be taken up by the expansion of the rubber. The makers allowed for an expansion of $\frac{1}{4}$ in.

It should be explained that in the process of manufacture the upper part of the still is cooled by the admission of cold liquor, causing a contraction of the metal in that part, and it was for the purpose of providing for this contraction that the rubber joints were designed. The vessel was set upon a concrete floor in the first instance, and as originally supplied was not fitted with a safety valve, but one was subsequently fixed by the owners. The steam supply was from two Lancashire boilers generating 130 lb. of steam, but between the main steam pipe and the still, there was a reducing valve, reducing the steam to 50 lb., and between the reducing valve and the boiler there were two more safety valves.

Gases were produced in the still in the process of manufacture of liquid ammonia, and these created pressure in the still in combination with the pressure created by the amount of steam admitted. In these conditions the still was set to work. In the year 1907, the owners fixed new stays, lengthening them so as to fix coiled springs to them at the upper ends of the stays. The reasons for the addition of these springs was that the light oils in the liquor entering the still acted as a solvent of the rubber joints and the tendency of the joints to leak was greater on that account.

The method adopted was to adjust the springs to the conditions of working under steam, and later when the upper part of the still became cool to tighten up the nuts holding the springs. The effect of this was a complete departure from the first method designed by the inventor, for in the early method the stays were adjusted to the still when hot, and when the upper part of the still became cool the slight space between the joints would be filled up by the rubber. In the new method adopted, the stays being tightened up to the conditions of the still when cool, there was little or no space between the metal joints when the contraction took place. Everything then depended on the strength of the springs and their capacity to provide for further expansion. If the springs did not allow of this expansion of the still when it was hot, after being adjusted when it was cold, the whole of the sections became converted into a rigid structure.

The steam pressure at which the still was worked had in the meantime been increased, and the safety valve set to blow-off at 12 lb. instead of the 6 lb. to 8 lb. pressure at which the owners had in 1904 announced their intention of working the still.

In the working of the plant it was particularly necessary to guard against the choking of the gas main and the passages to the safety valves of the still, to which they were peculiarly liable in this process. A deposit of ammonia crystals rapidly took place at times, and to facilitate the removal of the obstruction, connections were provided on the still which enabled steam to be blown into the pipes.

In 1912 the still was put upon a platform, to allow of the discharge of the effluent from the still by its ordinary pressure and by gravitation instead of having to be pumped, as it had been, into a secondary still.

On the statement of Mr. Blackburn, the company's works manager, the pressure was certainly increased at this time, and it was increased from 12 lb. to 15 lb. It was not quite clear at what pressure the safety valve was set to blow-off at this time, but on the evidence of Mr. Speight, one of the still operators, it was, if not blocked by crystals, at full blow at 17 lb., and this pressure was necessary to force the liquid into the secondary still. Speight also stated that he sometimes preferred the safety valve to be blocked with crystals, because he could then work the still comfortably. The Commissioners state: "It is almost incredible that a boiler could have been worked, and allowed by the responsible officials at the works to be worked, under such dangerous conditions."

At this time the stays were lengthened, and the springs made longer and stronger. The object, as stated by Mr. Blackburn, was to put increased pressure on the still. The increased length of the rods was to allow of another tray being added. These springs were the same as were on the boiler at the time of the explosion.

In 1917 six stays were renewed. They were showing signs of weakness, due, it was said, to rust. It was not known whether the new ones were distributed round the still or not, or placed all together. All the stays, having been renewed in 1912, there were, therefore, at the time of the explosion six stays ten years old, and six five years old. As far as could be ascertained, no one with any knowledge of boilers under steam adjusted the nuts holding the springs, though the safe working of the still depended upon the care with which this operation was performed. Everything, in the opinion of the Commissioners, seemed to have been left to chance in the working of this boiler. From tests made by Mr. Whitelock, the chief engineer of the company, after the explosion, it was proved that the springs showed a total compression of $\frac{1}{4}$ in. with a load of $3\frac{1}{2}$ tons, and from that he came to the conclusion that the springs were screwed up tight. The strain on each stay was, as stated by him, exactly this amount when there was a pressure in the boiler of 15 lb. per square inch of steam. When greater pressure was in the still, as was generally the case, there would be greater strain on the stays, while on occasions the pressure in the still rose to 20 lb., and even as high as 25 lb. The Commissioners, therefore, came to the conclusion that the springs were, for all practical purposes, screwed up tight.

The safety valve afforded little security to the operator. It constantly became choked with the ammonia crystals already referred to. Mr. Jackson, who had been in the employ of Messrs. Brotherton for thirty-one years, fifteen years of which he had been foreman, stated they frequently had to steam out the safety valve to keep it clear of crystals, and that sometimes this was done as often as two or three times in an hour, and then a week might elapse without having to steam out the valve more than once or twice. Other evidence was given to the same effect.

Dealing with the explosion, the Commissioner reports, the still had been put off work from July 15 to 31. The still man whose shift it was, was a man named Gibbon, and he arrived at the works at 6 o'clock on July 31 to put the still into use. Both Gibbon and the man in charge of the lime agitators for this still were killed, and there was, therefore, very little information available as to what took place on that morning. It was known that another still man named Rathby went with Gibbon on that morning to work, and was with him at the still for some time. He saw Gibbon put the steam on to the lime agitators, then on to another still called the finishing or secondary still, and then put the steam to clear out the crystals in the 2-in. pipe leading to the scrubbers. Rathby heard Gibbon say that the pipe was clear. The explosion occurred a minute or two after 7.30. The *debris*, after the explosion, was found round the secondary still in two heaps not more than 8 ft. away from the position of the still on the platform before the explosion. Two or three small pieces had been projected to a considerable distance.

Dealing with the question of the cause of the explosion, the Commissioners were of the opinion that the still exploded owing to the breaking of the stays. The stays were found corroded on the outside, and as to two of them they had lost their requisite elasticity on that account. The pressure in the boiler might partly account for their giving way, but when the still became heated and the metal expanded, these stays were subjected to a very great additional strain beyond the strain due to the pressure in the still. If the springs were screwed up tight, the stays, in their effort to hold the still against this expansion, broke because they could not withstand the strain.

Dealing with the responsibilities of the parties to this inquiry, the Commissioners found that the company was chiefly responsible, the works being under no proper skilled engineering supervision. The company employed as their works manager Mr. Blackburn, who was no doubt a very able chemist, but, in the Commissioners' opinion, from his acts and conduct in relation to this still, he lacked the engineering knowledge necessary to take charge of boilers. These appointments of men to fill the dual capacity requiring scientific skill suitable to a particular trade and as engineers as well, in which they have no special training, have caused many explosions of boilers, and the Board of Trade have frequently called attention to the risks which owners run in making such appointments. Besides this, and without any skilled advice, the company used the still at a pressure far beyond the pressure for which it was designed, and they again and again increased the pressure for their own reasons, partly, no doubt, for the sake of economy. No one on behalf of the company had been called to show that the company took precautions or gave instructions to any of their responsible officials as to the working of this still, and there was nothing to show that the directors were not fully aware of the conditions under which it was worked.

The report concludes with the following questions put by Mr. Vaux, and answers by the Commissioners: Question 1: "When and by whom was the still which exploded made?"—Answer: "By Ashmore, Benson, Pease and Co., in 1903." "When was it set up at the Holmes-street Works, Leeds?—Answer: "In 1904."

Question 2: "After being set up at the Holmes-street Works, at what pressure was it worked?"—Answer: "At varying and increasing pressures to which we have already referred." "Was the safety valve fitted to the still of sufficient area to prevent over-pressure?"—Answer: "No." "Was the still worked at a safe working pressure?"—Answer: "No."

Question 3: "Were the springs on the upper ends of the stays of the still, fitted in or about the year 1912, suitable, and so arranged as to adequately meet the stresses imposed upon the stays in the normal working of the plant, and to allow for the free expansion of the still in a vertical direction?"—Answer: "No."

Question 4: "On the morning of July 31 last, were proper measures taken to ensure that the pipes of the still were kept free of crystals before the explosion occurred?"—Answer: "The 2-in. pipes leading to the scrubbers was clear, but we have no evidence as to whether the safety valve and outlet in the dome were clear."

Question 5: "Was the working of the still entrusted by Messrs. Brotherton and Co., Limited, to a competent person or to competent persons?"—Answer: "No."

Question 6: "Did the Company and their works manager, Mr. Herbert Henry Blackburn, take proper measures to ensure that the still was worked under safe conditions?"—Answer: "No."

Question 7: "What was the cause of the explosion of the still at or about 7.30 a.m. on July 31 last?"—Answer: "We have fully answered this question before."

Question 8: "Are Messrs. Brotherton and Co., Limited, and Mr. Herbert Henry Blackburn, their works manager, or is either, and if so, which of them, to blame for the explosion?"—Answer: "The company is partly responsible, with the still man, Gibbon, for the explosion which occurred. There is not sufficient evidence to show that Mr. Blackburn is responsible." "Should they, or either of them, pay any, and if so, what part of the costs of the formal investigation?"—Answer: "We order that the company pay 200*l.* towards the costs of this inquiry."

The Commissioners desired to thank Mr. Vaux for the able and careful way in which he had presented the case. They also sincerely deplored the loss of two lives in this explosion, and wished to express their condolences to the relatives. Since the explosion, the company have done what they should have done before. They have entrusted their chief engineer with the erection of a new still to suit the work demanded of it. The base of the still has been strengthened, as well as the stays, and much stronger springs have been fitted. The chief engineer has taken upon himself the important duty of adjusting the springs. The position of the safety valve has been altered and improved, and the area of the valve increased. The still has been tested by hydraulic pressure, the strength of the platform on which it stands has been increased, and the still has been tied down to the platform.

A NEW LONG-LIFE MOULD DEVELOPMENT.*

By Dr. R. MOLDENKE, Watchung, N.J.

THE foundryman has always felt that the destruction of the mould every time a casting is poured is an inefficient procedure. Indeed, the making of moulds which could be used over and over again dates back to the bronze age, when implements of warfare and domesticity were made in stone moulds the two parts of which were suitably hollowed out, clamped together, and poured much as our present brass ingots. These stone moulds are in reality the first "long-life" moulds on record. In the development of the iron industry, with molten metal at first only as an undesirable occurrence in the operation of the small blast furnaces used, the open-sand mould was the only practical means of caring for the intermittent supply of metal. As time went by, however, and the iron foundry became stabilised, the desire to construct moulds which would last for more than one filling without damage asserted itself again, and as early as the opening of the last century we have English patent records bearing upon the subject.

While the iron mould—or as we knew it under the title of "permanent mould"—has been known and used for perhaps a century and a half, and is to-day attracting world-wide attention in connection with the centrifugal casting process, the method in its simpler forms has never found a solid footing in the foundry industry, the fundamental reason being that the molten metal when poured into an iron or steel mould is subjected to entirely different influences than is the case with the ordinary sand mould. The rate of cooling is much faster, with consequent more sharply defined crystallisation effects, and production of very fine grain structure if not actual chilling of the metal to whiteness. Even where the attempt is made to approximate the rate of cooling, to that of the sand mould, by suitably preheating the iron mould, this either falls short of the desired situation if the mould is to last, or when preheated sufficiently, pouring must be done at longer intervals unless the life of the mould is to be sacrificed. The consequence has been that while good castings have been made with all the permanent mould processes brought out, the irregularity of product unless corrected by careful and costly annealing has militated against their commercial success.

For ordinary work, therefore, it seems far better to return to the old bronze age idea of using the equivalent of the stone mould—in other words, a mould of the refractory surface properties of sand and yet strong enough to yield a large number of acceptable castings before considerable redressing is necessary or the mould must be discarded. This would be the "long-life" mould. Coming down to practical considerations, the following conditions would seem to be indicated in developing such a type of mould.

First.—The mould surface must be of a highly refractory character so that the least possible heat may be transmitted inward to affect the form of the mould as well as seriously limit the rate of pouring iron for castings into it. If too much heat passes from the surfaces in contact with the molten iron into the body of the mould, the very purpose of the mould is lost, as it no longer will approximate the regular sand mould. Again, a too hot mould will warp and deteriorate rapidly. Hence the desirability of having the mould light and if necessary air cooled, so that the mould body may not accumulate heat unduly and thus affect the rate of pouring detrimentally. The ideal situation is that of the heat conditions in the green sand mould from which the casting has been removed just after setting—imagining this possible without destroying the mould. But a very small depth of sand will have been seriously affected by the extreme heat, and the outer portions of the mould may still be cold.

Second.—The nature of the mould material must be such that no gases are formed during contact with the molten metal, until this has set. There is little chance for venting in such a mould. A momentary consideration of this matter, however, will show that after all it is the fault of the mould if gases are formed which affect the metal surfaces. The chilled roll is a case in point. Here is no chance for venting whatever, and yet castings are made which machine up without a defective speck. Further, it is perfectly possible to cast against a fire-brick surface successfully, provided the surfaces are perfectly dry and preferably warmed. Hence, if the casting surfaces of a long-life mould are of a finely granular and highly refractory nature there need be little fear of bad results due to lack of venting.

Third.—The mould surfaces must be sufficiently strong to resist the cutting action of the molten metal, and be impervious to the entrance of fine filaments of iron which, on removal of the casting, would take some of the mould material with them. Further, the mould surfaces must not spall off. If thoroughly dried the last named action should not eventuate. The strength of the mould surfaces is a question of the bond, and the porosity of the material a matter of the fineness of grain or crystal.

The crucial point in the above considerations as to the nature of a desirable mould surface is the rate of removal of heat from the molten metal—whether as slow as in the case of the ordinary sand mould, or fast enough to permit some chilling action. This rate of removal of the heat until the molten metal has safely set depends upon the refractoriness of the material in greatest measure, the temperature of the molten metal and the quantity of metal involved, and on the freezing point and other metal characteristics. For the various sections of a casting the temperature of any point of contact between mould surface and molten metal will be practically the same at first, but the depth to which the comparatively high temperatures will penetrate the mould mass will naturally depend upon the thickness of the metal which has to set against it. Thus, if in a casting, that portion $\frac{1}{2}$-in. thick imparts, say, 1,000 deg. F. to a point $\frac{1}{2}$-in. within the mould mass, another portion of the same casting 2 in. thick may show the same 1,000 deg. F. at a point $\frac{1}{16}$ in. deep within the mould mass before the metal has safely set. Practically, for "long-life" mould purposes, it is the nature of this $\frac{1}{16}$ in. or less—depending upon the thickness of the castings to be made—that must be carefully considered and conform to the requirements above enumerated. The rest of the mould mass can be any material that is structurally safe to hold the refractory surface true and well bonded, and will also absorb the heat passed through the mould surface material and promptly dissipate it. In other words, a cast iron backing to a refractory mould material forming a contact surface for the molten iron, is an ideal combination when the refractory facing of the mould is heavy enough to transmit heat at the proper safe rate, and the iron backing is light enough to dissipate the heat transmitted into it quickly.

With the above underlying principles involved in the construction of the "long-life" mould thus enunciated, it is the purpose of the writer to show how the problem of adapting these principles for everyday practical application has been worked out into a system by the Holley Carburettor Company, of Detroit, and to show illustrations of the machines built for the purpose. When it is stated that by this time some of the moulds have already had ten thousand castings made in them and by reason of a close daily inspection of and attention to the refractory facing material of the moulds, not one of them has yet had to be discarded, the writer feels that here is truly a new development in making long-life moulds. The term "long-life" is used advisedly as against "permanent," for in the latter the supposition is that no repairs are made on the metal mould; whereas in the

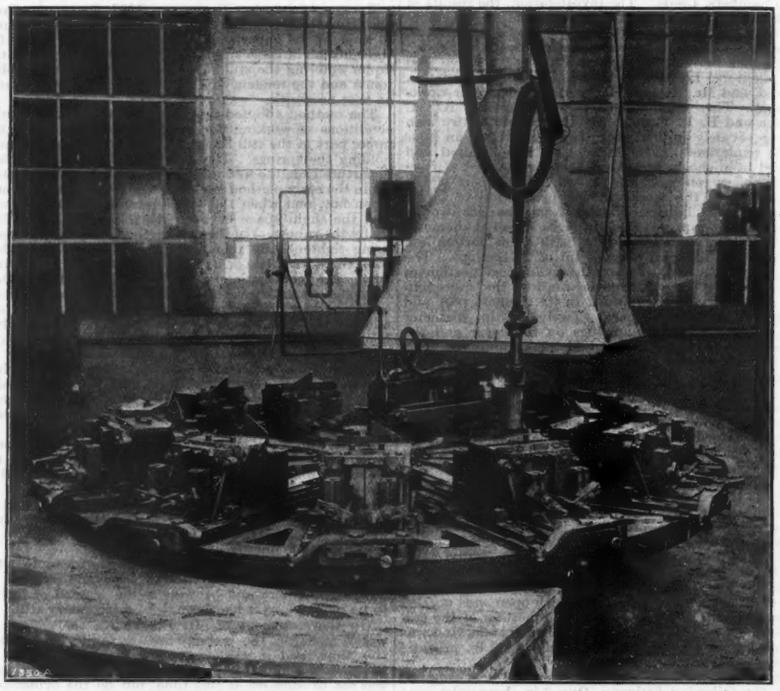


FIG. 1. GROUP OF LONG-LIFE MOULDS ON REVOLVING TABLE READY FOR POURING.

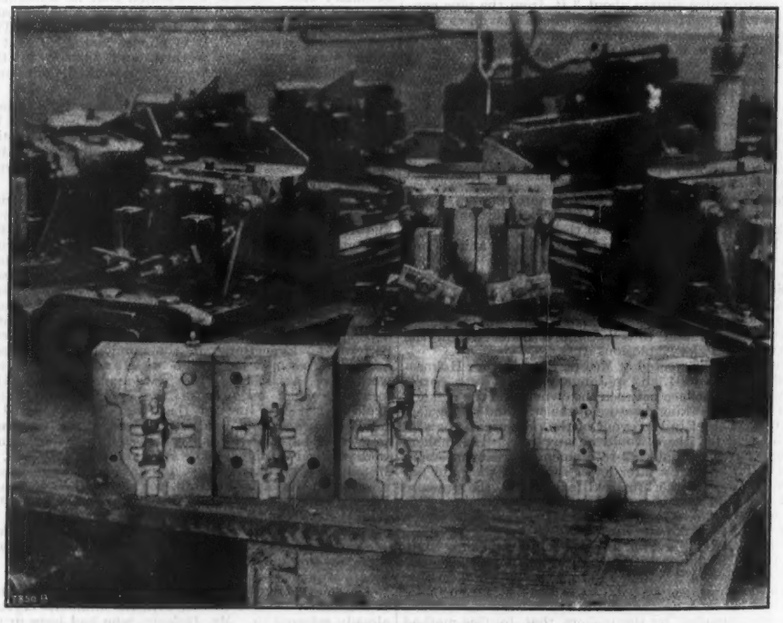


FIG. 2. MOULDS WITH CASTING MODELS.

* Paper read before the American Foundrymen's Association, May 3, 1923.

former, repairs are possible and are carried out until they no longer pay.

The system devised by the Holley Carburettor Company has been carefully worked out in every detail and is fully patented. The several steps and the reasons for operating in the particular way adopted are:—As previously indicated, the primary idea has been to make a very light cast iron mould, the surface of which is covered with a layer of highly refractory material, of necessary thickness, and this refractory material so protected from abrasion and penetration of fine iron filaments, that it almost wears to a polished surface and a mineral one, an alkali silicate being most convenient, so that when heat has been applied the mass is like a thin sheet of stone. The material is preferably put on in comparatively thin layers, and each one baked on before the next is applied. For the heavier facings, the final layers can be applied by transfer from what would be a metal pattern, so that the accuracy of the finished long-life mould leaves nothing to be desired.

The final heating—in effect a skin-drying at temperatures to almost vitrify—being accomplished, the moulds are placed in their proper position on the revolving table, and successively follow their prescribed course. In

FIG. 3. CASTINGS AS EJECTED FROM THE MOULDS AND PARTLY MACHINED.

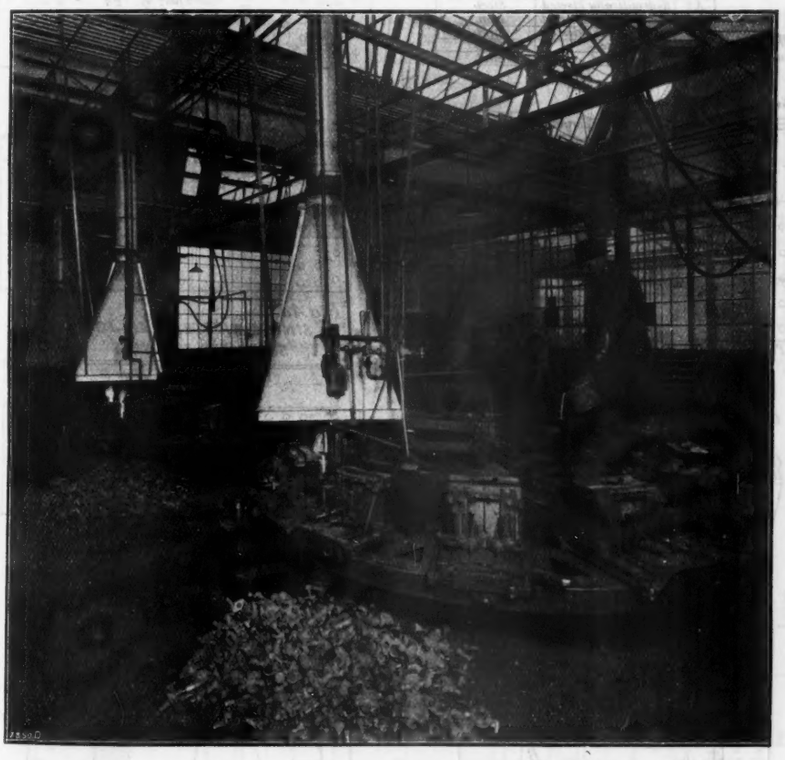


FIG. 4. TWO OF THE TABLES IN OPERATION.

only on rare occasions need be patched up or refaced. For operating purposes, where the castings are not large, a group of moulds is placed upon a revolving table and the several steps of the cycle can be carried out almost completely automatically. Where the castings are larger and a table of three to eight moulds would be cumbersome, single moulds would be operated as long as molten metal is available.

The refractory material forming the mould surface consists of two items. The refractory material itself, and the binder to bond it to the iron backing. The refractory material can be of any of the usual substances used to resist heat in the arts. Thus magnesia, bauxite, fire-clay or kaolin will serve. The grain must be exceedingly fine, and in the application heat must be used finally, so that no question of gas-forming constituents remaining in the mass may arise. The binder must be passing round, the two parts of the mould are drawn apart sufficiently to allow the setting of cores, but just before this each mould successively passes a flame of acetylene gas which smokes the inner surfaces heavily. The idea of this is to interpose a film of carbon between the refractory surface and the molten metal of sufficient strength to effectively prevent any scoring action or the actual contact of metal and refractory material. This for the instant of greatest temperature effect. Most of the carbon is absorbed by the metal, but the effect is that, until the molten metal is no longer dangerous, the refractory material is protected. After passing the flame and the position where cores can be set, the two parts of the mould are made to close automatically and are held thus until poured off and the metal has sufficiently set. Then they quickly open and the castings are forced out by pins or in other suitable ways. Next, the blast of air at high pressure rapidly blows the surfaces clean and the mould passes before the acetylene flame again. The man setting the cores, or, in their absence, any attendant, watches out for the mould surface condition as the moulds pass by open, and any fragment of iron or core left in the mould is easily removed with a suitable tool.

The iron backing of the mould has been stated as comparatively thin. This allows—particularly if constructed with that in view—the use of air-cooling action, and where such an air blast for cooling the iron moulds a little faster than they would normally do, is in use, the machine can be speeded up so as to give a large production.

Whether pouring is done by hand or from suspended ladles; whether the man remains stationary while pouring as the mould passes him or a moving platform accompanies the table; whether the moulds and cupola are together or iron has to be carried from a distance; and, lastly, whether moulds are poured all day long or merely the usual two or three hours, depends upon the individual situation. It may be of interest to state that, with twelve single moulds on the revolving table, one man can pour 400 castings of a given kind per hour. With sand casting it takes eight times the number of man-hours to get an equal number of the same kind of castings. Further, from the nature of the pour—top-pour—it is possible to feed the moulds more perfectly and hence the castings made are quite free from shrinkage, even with considerable variation in sections. This makes for denser metal and the consequent benefit to strength conditions, &c.

While the process is still in its infancy and attention has naturally been given to quantity production of the comparatively light castings required at the Holley Carburettor Works, nevertheless many automobile pistons have been made also, and these involve somewhat thicker sections. It will become a matter of heavier refractory coatings, and more frequent repair of exposed points in these coatings, when larger work is undertaken.

Of the illustrations given, Fig. 1 shows a group of long-life moulds arranged on the revolving table and ready for pouring. Directly at the wooden platform at its right end the mould will be noted just closing up. The next five moulds will be seen as closed. Pouring is done while the moulds pass the wooden platform. The metal sets properly while the table brings the moulds successively to the position of the one under the last pipe at the left, where the moulds open for the ejection of the castings. At the next position toward the right the mould face is blown clean; then it comes before the acetylene flame, as seen directly under the hood. Here the mould face is smoked, the excess smoke being drawn away with the products of combustion. The moulds are now quite wide open and at the extreme right of the table, three moulds can be seen fully open for inspection and the setting of cores. The cycle then repeats itself.

Fig. 2 shows the moulds more plainly and also has placed in the foreground a set each of a one and a two-casting mould. The arrangement for pouring basin, core vents and gating is plainly shown. A core has been set in the third mould from the left. The holes in the moulds directly in the spaces for the molten metal are filled with suitable pins which push inward as the moulds open and thus eject the castings automatically.

Fig. 3 shows some of the castings as ejected from the moulds and partly machined. Also a broken casting with perfectly uniform, fine-grained fracture, easily machinable and without a sign of chilling. The piston casting shows some thick sections, not being cored for the pin. The pair of castings connected with the gate, at the extreme right, are interesting as being taken from the right-hand mould pair of Fig. 2. The cores have been removed.

Fig. 4 shows two of the tables in operation. Pouring off may be observed on the first table, and the smoking of the moulds on the first and second. Successful results have also been obtained by spraying the moulds with a film of graphite in oil, the heat of the moulds driving off the oil almost immediately. This method would doubtless be more economical for larger moulds.

It has been of great interest to the writer to observe the operation of the Holley development. For many years he has advocated leaving the "permanent mould" idea in favour of the "long-life mould," as giving promise of better results, if not as spectacular. The principles involved have also been discussed by the writer, but until the Holley Carburettor Company had worked out the problem step by step and had provided for the several contingencies mentioned in connection with the requirements of the mould surface, nothing comprehensive in this line had come before the foundry industry. It is with genuine pleasure, therefore, that there have been given as the title of this paper the words "A New Long-Life Mould Development."

FURTHER EXPERIMENTS ON LARGE-SIZE RIVETED JOINTS.*

By MR. J. MONTGOMERIE, D.Sc., Member.

FROM 1917 to 1920 the author undertook, on behalf of the Committee of Lloyd's Register of Shipping, an experimental research on the elastic properties of riveted overlap joints such as are ordinarily used in shipbuilding. This research was carried out on joints manufactured by Messrs. Harland and Wolff, Limited, and the tests were applied by the large machine in Lloyd's Proving House, Glasgow. A detailed report of the experiments, setting forth the results found and stating the conclusions derived from them, was made to the committee in February, 1920, and was thereafter published by them in

* Paper read before the Institution of Naval Architects, March 23, 1923. The paper is accompanied by an appendix dealing with the bibliography of the subject, which we regret we have not space to reprint.—[ED. E.]

May, 1920. These experiments were made on 12 plates, six of which were 0·44 in. in thickness, connected by treble riveted overlaps, and six of 0·58 in. in thickness, connected by quadruple riveted overlaps. The general conclusions derived from the experimental work were set forth in the report and are as follow :—

(1) The assumptions underlying the theory on which the design of riveted joints rests are not valid, *i.e.*, the load is not distributed evenly among the rivets, and no uniform state of stress exists anywhere in the joint.

(2) For pulls up to the point at which "slip" takes place the maximum stress occurs in each plate on the surface next to the edge of the joint. At this point the stress is nearly double that in the normal plate. On the opposite surface the material is practically relieved of stress. The average stress across the thickness of the plate is therefore approximately the same as that found in the normal plate.

(3) "Slip" takes place in the joint when the pull applied, distributed over the area of the rivets, produces a stress figure of from 7·5 tons to 8 tons per square inch. Up to that point the joint behaves as an elastic solid. After an interval the joint recovers its powers of adhesion, and gives a similar result, on re-testing, to that already obtained.

(4) The pull producing "slip" when referred to the sectional area of the normal plate, and to the area of the material between a line of frame rivets spaced 7 diameters apart, corresponds with a mean stress of 9 tons per square inch and 11 tons per square inch respectively.

(5) No appreciable distinction can be drawn in regard to the elastic qualities or ultimate strength of the joint in respect of the method of riveting employed, or the rivet material used.

(6) The average strain, measured over the whole joint, does not materially differ from that found in the surrounding material.

(7) In a lapped joint the rivets in the outer rows are more severely stressed than those in the inner rows.

Following on the publication of the results of these experiments, a letter was received from Viscount Pirrie, a member of the Committee of Lloyd's Register, in which his lordship suggested "that if it was intended to continue these experiments . . . the next series should be with rivets two sizes larger, *i.e.*, 1¼ in. diameter, with correspondingly thicker plates in connection with which there seems to be less certainty as to what constitutes the most desirable practice. We are not, I think, entitled to contend, from the results of experiments on rivets ¾ in. in diameter and thin plates, that the same results will apply to rivets of a larger size and heavier plates on account of the increasing difficulties in good workmanship."

Following upon that letter the Committee of Lloyd's Register authorised a continuation of the experiments along the lines suggested by Viscount Pirrie. The following report is a history of this investigation, and sets forth the results obtained.

A series of 17 specimen joints was made by Messrs. Harland and Wolff, Limited, Govan, the particulars of which are shown in Figs. 1 to 4 inclusive. Twelve quadruple riveted joints were prepared, six of these being formed between plates of dimensions 13 in. by 1·04 in., the joint containing 12 rivets 1¼ in. in diameter. The remaining six were formed between plates of dimensions 19½ in. by 0·75 in., the joint containing 20 rivets 1 in. in diameter. In addition to the above, five other joints were prepared, formed between plates of dimensions 17 in. by 0·58 in. Two of these, F2 and F3, were treble riveted, one having a uniform spacing, and the other having the rivets in the outside rows more widely spaced than those in the central row. The remaining three joints, F1, E and D, were treble, double and single-riveted respectively, with the object of obtaining some relation between the point at which "slip" occurred, and the actual number of rivets employed. The joints were numbered as shown in the table opposite.

The plates, as in the former series of tests, were of ordinary steel of shipbuilding quality, and were attached to end forgings by means of steel bolts 1 in. in diameter, as shown in Figs. 1 and 2. The strain corresponding

Fig. 1. QUADRUPLE RIVETED LAP JOINT. 1" PLATES. 1⅛" RIVETS.

MARK	TYPE OF RIVETING	TYPE OF RIVET
A.1	Hydraulically Riveted	Iron
A.2	Hydraulically Riveted	Steel
B.1	Pneumatically Riveted	Iron
B.2	Pneumatically Riveted	Steel
C.1	Hand Riveted	Iron
C.2	Hand Riveted	Steel

16-1 Dia. Steel Bolts through Plates and Forgings.
Ordinary Mild Steel Plates used—Edges Planed.
Ordinary Shipyard Practice as for Shell Butts has been adhered to in Rivets and Riveting, except when re-riveted and stated otherwise in Text.
Bolt Holes in Plates and Forgings Drilled.

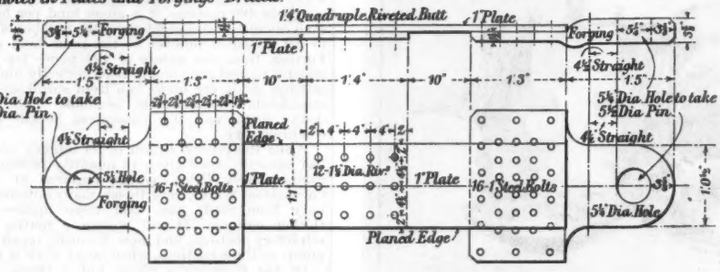


Fig. 2. QUADRUPLE RIVETED LAP JOINT. ¾" PLATES. 1" RIVETS.

MARK	TYPE OF RIVETING	TYPE OF RIVET
A.1	Hydraulically Riveted	Iron
A.2	Hydraulically Riveted	Steel
B.1	Pneumatically Riveted	Iron
B.2	Pneumatically Riveted	Steel
C.1	Hand Riveted	Iron
C.2	Hand Riveted	Steel

26-1 Dia. Steel Bolts through Plates and Forgings.
Ordinary Mild Steel Plates used—Edges Planed.
Ordinary Shipyard Practice as for Shell Butts has been adhered to in Rivets and Riveting, except when re-riveted and stated otherwise in Text.
Bolt Holes in Plates and Forgings Drilled.

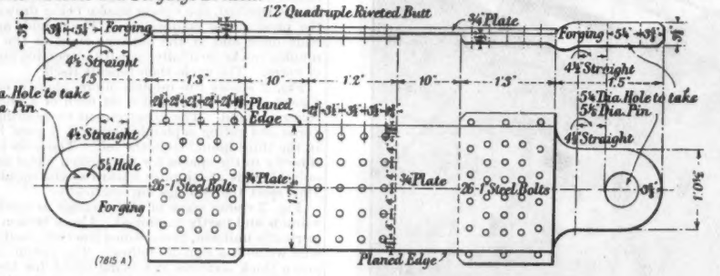


Fig. 5. GAUGE PLATES ELEVATION

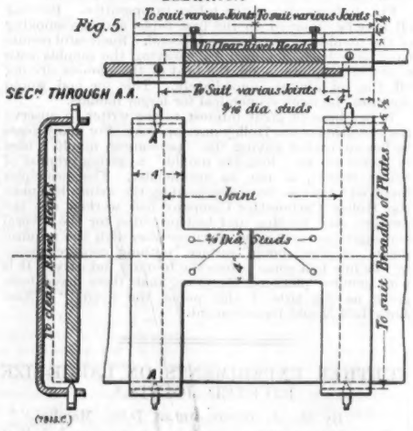


Fig. 6. ¾" PLATES. 1" RIVETS. SKETCH SHOWING EXTENT OF SURFACES NOT IN CONTACT.
RIVETED PNEUMATICALLY. IRON RIVETS

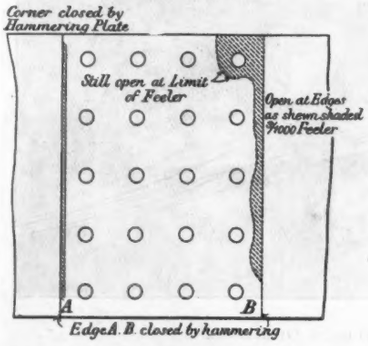

Corner closed by Hammering Plate
Still open at Limit of Feeler
Open at Edges as shown shaded 7/1000 Feeler
A
B
Edge A. B closed by hammering

Fig. 3. TREBLE RIVETED LAP JOINTS. ·58" PLATES. ⅞" RIVETS.

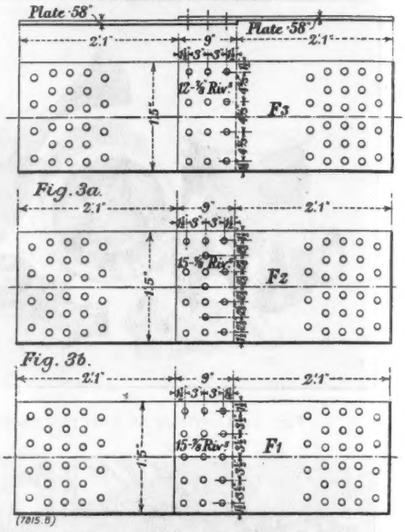


Fig. 4. DOUBLE RIVETED LAP JOINT ·58" PLATES ⅞ RIVETS

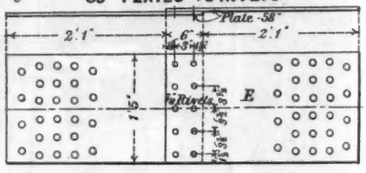


Fig. 4a SINGLE RIVETED LAP JOINT ·58" PLATES ⅞ RIVETS

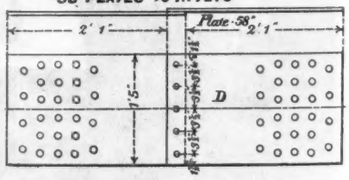
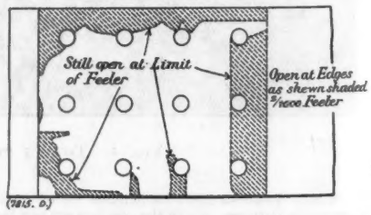


Fig. 7. 1" PLATES. 1⅛" RIVETS SKETCH SHOWING EXTENT OF SURFACES NOT IN CONTACT.
RIVETED PNEUMATICALLY. STEEL RIVETS



to any given pull was measured by a strainmeter carried by holders of the type shown in Fig. 5. These holders were attached to the two plates forming the joint by means of steel set-pins having sharp case-hardened points. The strainmeter was set so that the knife-edges engaged with the top surfaces of the gauge plates, and the strain measured was accordingly the total stretch occurring between the points of the set-pins. The strainmeter, a description of which has already been given in the Institution's Transactions, was carefully calibrated, one scale division representing a stretch of 0·000071 in.

appearance they seemed to conform with the average practice with which we are familiar in shipyards. The blade of an ordinary test knife could not be introduced between the surfaces, and the rivets appeared to fill the holes properly and to be efficiently laid up. A more detailed examination with thin feelers showed, however, that for considerable areas the plates were not in contact at all. Figs. 6 and 7 show the maximum extent to which this state of non-contact occurred, the shaded parts representing the areas in question. The effect of this will be referred to later.

terms of the stress in the unpierced material produced by the pull causing slip, and the stress in terms of the rivet area of the joint, are given in Table II. An examination of the Table II reveals the fact that the pull producing slip corresponds to a stress, when related to rivet area, which varies between wide limits. For purposes of general deduction joint B1 should be ruled out of consideration. This joint, on investigation, was found to be inefficiently closed (see Fig. 6). The safest conclusion that can be derived from this test is that a large loss of efficiency is entailed by imperfectly

Fig. 8. ¾" PLATES. 1" RIVETS.
NOMINAL SECTIONAL AREA OF RIVETS = 15·6 SQ. INS.

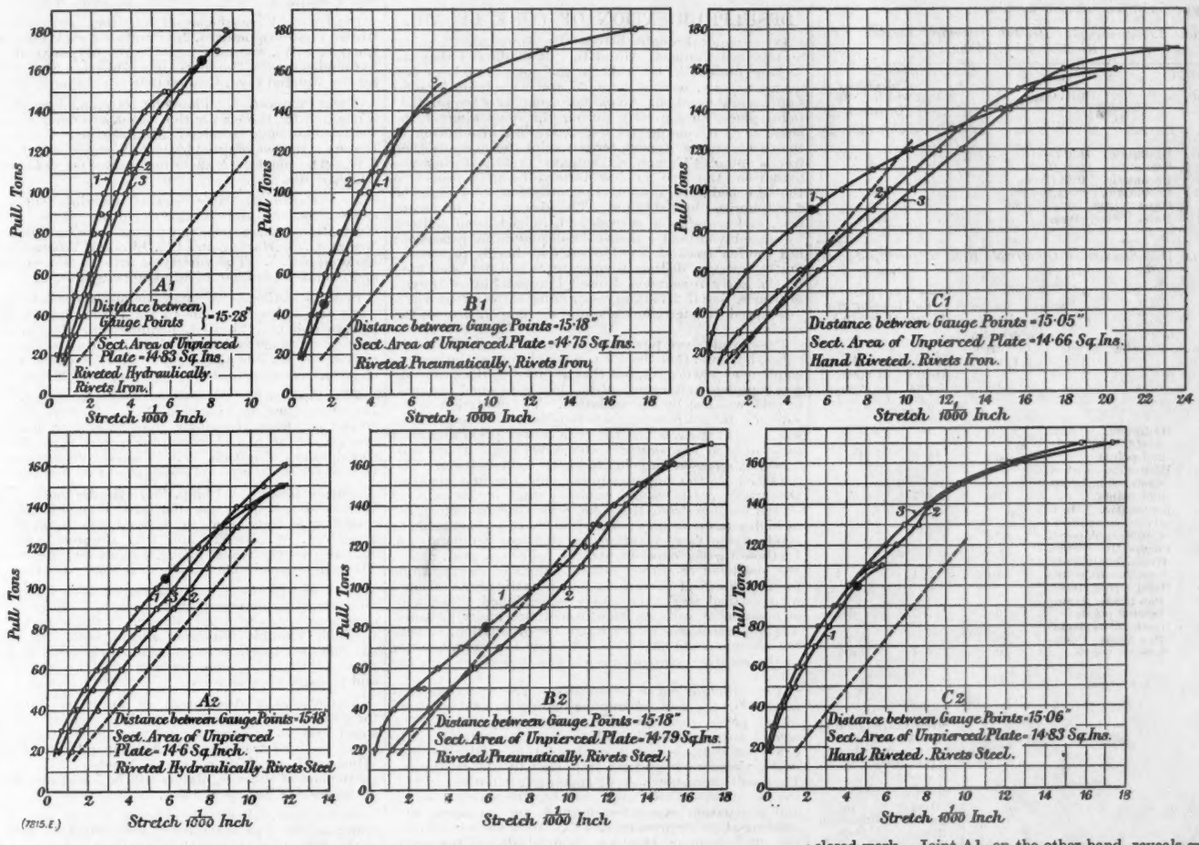
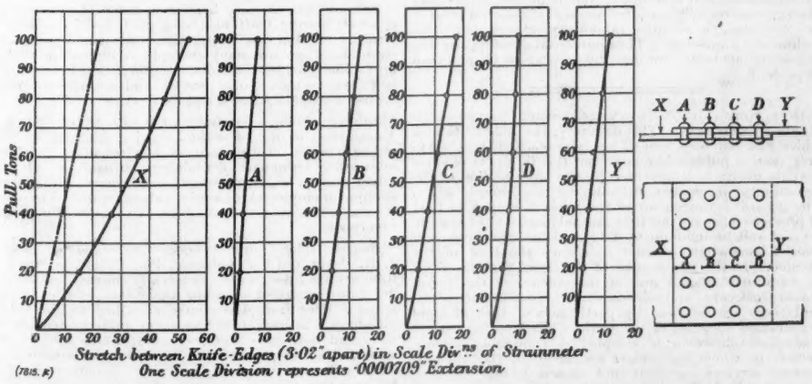

Pull Tons
Stretch 1/1000 Inch
A1
Distance between Gauge Points } = 15·28"
Sect. Area of Unpierced Plate = 14·83 Sq. Ins.
Riveted Hydraulically. Rivets Iron.
B1
Distance between Gauge Points = 15·18"
Sect. Area of Unpierced Plate = 14·75 Sq. Ins.
Riveted Pneumatically. Rivets Iron.
C1
Distance between Gauge Points = 15·05"
Sect. Area of Unpierced Plate = 14·66 Sq. Ins.
Hand Riveted. Rivets Iron.
A2
Distance between Gauge Points = 15·18"
Sect. Area of Unpierced Plate = 14·6 Sq. Inch.
Riveted Hydraulically. Rivets Steel
B2
Distance between Gauge Points = 15·18"
Sect. Area of Unpierced Plate = 14·79 Sq. Ins.
Riveted Pneumatically. Rivets Steel.
C2
Distance between Gauge Points = 15·06"
Sect. Area of Unpierced Plate = 14·83 Sq. Ins.
Hand Riveted. Rivets Steel.
(7815.E.)

Fig. 9. DIAGRAM SHOWING STRETCH ON UPPER SURFACE OF PLATES QUADRUPLE RIVETED. JOINT A2. 1" RIVETS. ¾" PLATES. STRETCH MEASURED ON LENGTH OF 3·02 INCHES.



The joints were extended by the large machine at the Glasgow Proving House, which is capable of exerting a pull of 180 tons, and the readings followed the usual conventional lines. Pulls of progressively increasing magnitude were applied to the joint. Zero readings were taken of the strainmeter, then a reading corresponding to the pull applied, and finally another zero reading.

It may be mentioned here that with the plates of thickness 0·76 in. and 1·04 in. much more difficulty was experienced in obtaining sequential results than had been found in the case of thinner plates. So pronounced did this difficulty become that a detailed investigation of the workmanship of the joints was made. To all

The main object of the experiments, of course, was to ascertain the relation of the elastic qualities of the joints to those ascertained in the former series, and the most important part of that investigation was the determination of "slip." "Slip" occurred when the final reading did not coincide with the initial one, and, in order to establish uniformity between the various cases, it was assumed to commence when this divergence attained an amount represented by five scale divisions of the strainmeter, and was found to increase progressively from that point.

The results are given in Table I, page 730.

The figures obtained by expressing these results in closed work. Joint A1, on the other hand, reveals great resistance to slip, but it is an isolated instance of its kind. It is an hydraulically-riveted joint, however, and the standard of workmanship was above the average. As the result of the test differs so widely from others conducted under similar conditions, it is not considered safe to derive any general conclusion from it alone. Having these considerations in view the table shows that the pull producing slip corresponds on the average to a stress of 6·2 tons per square inch referred to the area of the rivets in the joint, and 6·6 tons per square inch referred to the area of the solid plate.

Mark.	Type of Riveting.	Material of Rivets.
	Quadruple Riveted Overlaps. 1-In. Plates, 1¼-In. Rivets. ¾-In. Plates, 1-In. Rivets.	
A1	Hydraulically riveted	Iron.
A2	Hydraulically riveted	Steel.
B1	Pneumatically riveted	Iron.
B2	Pneumatically riveted	Steel.
C1	Hand riveted	Iron.
C2	Hand riveted	Steel.
	Treble Riveted Overlaps. 0·58-In. Plate, ¾-In. Rivets.	
F1	Pneumatically riveted	Iron.
F2	Pneumatically riveted	Iron.
F3	Pneumatically riveted	Iron.
	Double Riveted Overlap.	
E	Pneumatically riveted	Iron.
	Single Riveted Overlap.	
D	Pneumatically riveted	Iron.

It is to be noticed that in the case of material of this thickness (0·75 in.), not only are the results much more variable than those obtained in the thinner plates, but the average values of the stress figures are lower. A comparison is appended to Table II showing the stresses corresponding to the pull producing slip as given above, and as found for the quadruple riveted joints in plates 0·58 in. in thickness.

The curves showing the relation of stretch to pull are shown in Fig. 8, and on each the point at which slip is taken to have occurred is marked with a heavy black dot.

The principal point of interest in this connection is the fact that relative motion of the two surfaces takes place at an earlier point than in the thinner plates formerly experimented upon. In the latter case the curve showing the relation of strain to stress was fairly regular up to the point at which slip took place, and at this point there was a large difference between the initial and final readings of the extensometer. In the ¾-in. plates, however, this did not occur. Slip was much more gradual, besides occurring relatively sooner. In fact, the whole series of experiments showed that the adherence factor had not that importance in the thicker plates which it had in the case of the thinner material. The results show that the joint was capable of plastic deformation at pulls which correspond to stresses in both rivets and plate which are somewhat below the limits to which the designer is in the habit of working.

TABLE I.—*Quadruple Riveted Overlap Joints. 1-In. Rivets. ¾-In. Plates.*

Joint.	Riveting.	Pull (Tons) at which "Slip" Occurred.
A1	Hydraulic. Iron rivets	165
A2	Hydraulic. Steel rivets	105
B1	Pneumatic. Iron rivets	45
B2	Pneumatic. Steel rivets	80
C1	Hand. Iron rivets	90
C2	Hand. Steel rivets	100

TABLE II.—*Stresses in Quadruple Riveted Overlap Joints.*

Joint.	Riveting. Rivets.	Pull at which Slip Occurred (Tons).	Stress Corresponding to Pull Causing Slip (Tons per Sq. In.).	
			Over Area of Rivets.	In Unpierced Plate.
A1	Hydraulic. Iron rivets. Snap heads and points ..	165	10·5	11·1
A2	Hydraulic. Steel rivets. Snap heads and points ..	105	6·7	7·2
B1	Pneumatic. Iron rivets. Snap heads. Countersunk points	45	2·9	3·1
B2	Pneumatic. Steel rivets. Snap heads. Countersunk points	80	5·1	5·4
C1	Hand. Iron rivets. Pan heads. Countersunk points ..	90	5·7	6·1
C2	Hand. Steel rivets. Pan heads. Countersunk points ..	100	6·4	6·7

Joints.	Stress Corresponding to Average Pull Causing Slip (Tons per Sq. In.).	
	Over Area of Rivets.	In Unpierced Plate.
Quadruple riveted joint in 0·58-in. plate	7·4	8·6
Quadruple riveted joint in 0·75-in. plate	6·2	6·6

In addition to the principal observations above described, a series of subsidiary observations was made, and the results of this are shown in Fig. 9. These are plotted measurements of stretch taken directly from the plates near the joint and on its surface. Positions X and Y are taken on the upper and lower parts of the plate (Y corresponding to the lower part opposite X) as close to the edge of the lap as possible, and positions A, B, C and D are taken across the lap. The results of these observations are in accordance with those already obtained in the first series of experiments, and they are also in conformity with all our knowledge and experience of the subject of discontinuity. It will be observed that the surface of the plate in the position X is comparatively highly stressed, the figure being, in fact, more than double that represented by the application of the same pull to the normal unpierced plate. The position on the other side of the plate—that corresponding to Y—is comparatively free from stress; so also is the surface of the joint itself. It follows, therefore, that the state of stress from end to end of the joint is subject to great variation, and reaches a maximum along the plane of the two surfaces.

In connection with this point reference may be made to some cases of failure of boiler plates which formed the subject of a research by Dr. E. B. Wolff, who contributed the results to the Iron and Steel Institute, and which were published by that society in their vol. xcvi, No. 2 (1917). Dr. Wolff described the cracks which had developed in the seams of the boilers under investigation, their microscopical beginnings in the plane of separation of the two surfaces of the plates forming the joint and their continuations and extensions. He concluded that "all evidence points to a very peculiar form of destruction of the surface layers of otherwise very plastic metal." He examined the theory that the cracks were caused by fatigue, and stated that "only when it can be proved that, at the places where the cracks are found, abnormally high stresses can occur, may we accept fatigue as the cause of the cracks." He then embarks on an inquiry into the variation of stress across different forms of joints, and although the method employed may be criticised, yet in the opinion of the present writer there can be no doubt as to the correctness of his conclusions. They agree in general with those given above, it being noted that the present experiments are concerned (unlike Wolff's) with the surface layers themselves at which maximum stress occurs. Dr. Wolff did not offer any explanation of this phenomenon; in the opinion of the writer it is due simply to discontinuity, and is present to a greater or less extent, in all riveted joints.

(To be continued.)

DESULPHURISATION OF COKE BY AIR.

IN a paper brought before the American Chemical Society last January, Alfred B. Powell showed that the sulphur present in hot coke in the coke-oven is in two forms, namely, ferrous sulphide and as sulphur in solid solution in the carbon. An oxidation of part of the sulphide takes place subsequently during the quenching of the coke, so that commercial coke contains, in addition to the two forms mentioned, ferrous sulphates and adsorbed free sulphur. Though no sulphur is lost during the oxidation, the free sulphur formed being retained in the adsorbed form, it seemed possible that coke might be desulphurised by oxidation. The idea was by no means new, and remarkable success had, indeed, been claimed by some inventors for their coke-desulphuring processes; but the few researches published were hardly promising. Since, however, definite temperatures had not been used in the early researches, Powell (United States Bureau of Mines, Serial 2,469), in continuing his work on coke, attempted to determine the optimum temperature for the oxidation.

Passing air over powdered coke, electrically heated in tubes, he found that there was no oxidation of the ferrous sulphide at 300 deg. C., but that at 500 deg. the oxidation was complete in a few minutes, while less than 1 per cent. of coke was lost by the oxidation. The oxidation of the sulphide did not proceed more rapidly as the temperature was raised higher, whilst the coke consumption increased noticeably at temperatures above 600 deg. There was, however, a reason for going to higher temperatures. The oxidation of the sulphide forms only the first stage of the process; the second essential stage is the removal of the sulphur from the coke, which might take place at higher temperatures; and it was hardly practicable to conduct the two operations at different temperatures. In these further experiments, the coke was used, not in the powdered condition, but in chunks of sizes suitable for metallurgical operations. The heating was effected in a vertical steel tube and was combined either with evacuation or with aeration, sometimes under pressure. The apparatus was rather rough for evacuation, so that the vacuum could not be pushed below 4 cm. of mercury; in the aeration experiments air was passed through the tube.

Two different cokes were tested. The first coke contained 3·2 per cent. of sulphur mainly in solid solution, which gave small promise of desulphurisation. The second coke contained 1·31 per cent. of sulphur, only 0·84 per cent. being in solid solution, and this coke might therefore have been improved by the treatment. The results were, however, disappointing in both cases with the two chief methods tried, namely, alternating roasting and evacuation every few minutes for 20 times, and roasting at an air pressure of 4 lb. With the second coke the sulphide percentage was diminished, but there was an increase in the sulphates, so that little was gained. The sulphur is too tenaciously held by the coke to be removed by the means tried. Treatment of the red-hot coke with hydrogen might answer, if it were not ruled out by economical considerations; but hydrogen would only take up the free sulphur after removal of the iron present in the coke, a feasible laboratory experiment, but technically impossible. Thus industrial desulphurisation of coke by air treatment does not appear to be practical at present.

DIRECTORY OF SHIPOWNERS, SHIPBUILDERS AND MARINE ENGINEERS.—This directory, the 1923 edition of which has just been issued, has now reached its twenty-first year of publication, and from this fact it is obvious that its utility is appreciated by the large section of the community interested in shipping and shipbuilding. The general arrangement of the book is similar to that of previous editions, but the material has been thoroughly revised and brought up to date, and has also been condensed somewhat in order to reduce the bulk of the volume. In the first section of the book, lists are given of Admiralty officials and of the officials of the Royal Naval Dockyards and various Government Departments, and these are followed by particulars of the principal registration societies of the world. The greater part of the volume, however, is occupied by a directory of shipowners in which particulars are given of the officials, agents, services operated, and vessels owned by each concern. A similar, but smaller, section is devoted to shipbuilders, marine engineers and dry-dock owners, and in this section the capacities of the shipyards and engine works are given as well as the dimensions of dry docks available for repair work. Lists of consulting marine engineers and naval architects, and of trade technical and educational organisations connected with the shipping industry are also included, and finally there are exceptionally complete indexes to the whole of the contents. The directory is compiled under the direction of the editor of *The Shipbuilding and Shipping Record*, and is published by the Directory Publishing Company, Limited, 33, Tothill-street, S.W. 1, at the price of 20s. net.

CATALOGUES.

Steel Hardening.—An illustrated description of equipment for hardening stainless steel cutlery is given in a catalogue issued by Automatic and Electric Furnaces, Limited, 175, Farringdon-road, London, E.C. 1.

Roofing Material.—Specimens and priced lists of bitumenised felt for roofing, under-slating and damp courses are to hand from Messrs. Robert W. Blackwell and Co., Limited, 36, Emperor Gate, London, S.W. 7.

Switch Gear.—A set of switch gear for outdoor use and specially designed for the extension of electric current supply to thinly populated areas is fully described and illustrated in a catalogue issued by Messrs. Johnson and Phillips, Limited, Charlton, London, S.E 7.

Pig-Iron.—A catalogue of pig-irons received from British Pig-irons, Limited, 2, Victoria-street, Westminster, London, S.W., contains many notes of practical value to foundry men. The irons are produced in Staffordshire by the Midland Coal, Coke and Iron Company, Limited.

Water Purification.—Plants for softening and sterilising water and for the elimination of oil, are dealt with in a special catalogue received from Messrs. Wilson and Perrett, Limited, Fairfield-street, Wandsworth, London, S.W. The plants are made in all sizes for industrial or domestic use.

Steel Furniture.—New lists of shelving, cupboards, clothes lockers and similar furniture of steel, with illustrations, dimensions and prices, have been issued by Messrs. G. A. Harvey and Co., Limited, Woolwich-road, London, S.E. 7. The variety of articles is considerable and includes a number of adjustable designs.

Resistance Alloys.—A catalogue of electrical resistance wires and strips has come to hand from Messrs. Henry Wiggin and Co., Limited, Birmingham. It contains a description in general terms of the qualities and practical uses of the various alloys, followed by a series of tables of properties and dimensions of wires and strips.

The Audiometer.—Messrs. Adam Hilger, Limited, 72A, Camden-road, London, N.W. 1, have issued a special catalogue describing the audiometer, an instrument which gives a photographic record of the forms of sound waves of speech, &c. The instrument may also be used for the analysis of noises produced by machinery.

Marine Motor.—A 10-h.p. four-cylinder marine engine to run on petrol or paraffin with reversing gear and propeller is illustrated in a catalogue received from Messrs. J. W. Brooke and Co., Limited, Lowestoft, who also supply tanks, piping, &c., as may be required. The engine is suitable for pleasure boats or other craft.

Oil Mill Machinery.—A small equipment for crushing and extracting oil from nuts and seeds is illustrated in a catalogue received from Messrs. Hollings and Guest, Limited, Thimble Mill-lane, Birmingham. The plant, suitable for export, includes engine and boiler, hydraulic press, kettle, rolls, edge runners, mills, pump, oil tank and pressure control valve.

Regulators.—A description of automatic regulators for pressure, temperature, humidity, density, vacuum, speed and other purposes is given in a 16-page catalogue received from British Area Regulators, Limited, Windsor House, Victoria-street, London, S.W. 1. Full particulars of these regulators will be found on page 167 of our issue of February 9 last.

Switch Gear.—Ironclad oil-break switch gear of the non-drawout type for mining and industrial purposes, is the subject of a special 36-page catalogue issued by the British Thomson-Houston Company, Limited, Rugby. This same firm send a list of ratings, prices and shipping measurements of hand-operated oil-immersed starting rheostats for alternating currents.

Small Craft.—A very handsome series of illustrations of small marine craft has been published in catalogue form by the Parsons' Motor Company, Limited, Southampton. There are many examples of fine sailing yachts up to 350 tons, with auxiliary motor power; as well as launches, cutters, motor barges, and stern-wheel boats for use in shallow waters, and for ferrying.

Salvage Plant.—Although the Liverpool Salvage Association is not a manufacturing concern in the ordinary sense of the term it has recently issued an interesting catalogue containing illustrations of the ships, pumps, air compressors, workshops, and general equipment employed for marine salvage work. The office of the association is at A.20, Exchange Buildings, Liverpool.

Boilers.—The "uniflow boiler" as made by Messrs. J. K. Petty and Co., Lebanon, Pa., U.S.A., is a multitubular fire-tube boiler, externally heated, with the fire tubes arranged to allow the water to rise in two straight lines from the centre and flow to the sides. "Uniflow" is used, in this case, to imply uniformity of flow, and not, as is more common in this country, to signify a uni-directional flow. The catalogue is interesting but the illustrations would be clearer if reproduced on a larger scale.

THE SURVEYORS' INSTITUTION.—Mr. James Inglis Davidson, Saughton Mains, Corstorphine, Midlothian, has been elected president of this Institution for the coming year, and Sir Edwin Savill (London), Mr. J. D. Wallis (Manchester), Mr. Dendy Watney (London), and Mr. H. M. Cobb (Rochester), vice-presidents. The new members of council elected at the recent ballot were Mr. J. F. Bowden (Exeter), Mr. Stanley Hicks (London), and Sir Harry Courthope-Munroe, K.C., the latter being an associate member.